Aide-Mémoire

TO

THE MILITARY SCIENCES.

PART D. E. F.

CONTAINING

*** THE BINDER *is requested to cancel this page of 'Contents'—the 'List of Plates'—and the 'Notice of the second Part,' on binding the volume.*

LIST OF PLATES.

* Nos. VII. VIII. IX. X. and XII. of 'Field Sketching' are double Plates.

FIFTY SINGLE AND SIX DOUBLE PLATES, BESIDES WOOD-CUTS.

NOTICE

OF

THE SECOND PART OF

THE AIDE-MÉMOIRE.

THE Editors have the pleasure of offering to the Military Profession the second Part of the 'Aide-Mémoire,' for it is framed for the assistance of all branches of the Service, without reference to any special department of the Army.

Notwithstanding that in a time of profound peace, the necessity for reference to such a work as this may seem remote, it is not the less desirable to take the opportunity afforded by the repose to collect in a condensed form what is useful in the field, and lessen the burden of carrying a large library of reference on the Art of War.

The Editors solicit, for the purpose of making the work as perfect as possible, such remarks or suggestions as will lead to improvements or amendments, or the correction of any errors of omission, which will be noticed in the subsequent parts or editions of the 'Aide-Mémoire.'

The cost of this work, in which the Contributors and Editors have no interest or advantage whatever, is divided among the copies first struck off, the Publisher's profit consisting in the copyright.

The Editors finding that the bulk of the work intended for the use of the Army generally, by the nature of the contributions, was more comprehensive than they anticipated, have decided upon dividing it into two volumes.

G. G. LEWIS, Colonel, R.E.
H. D. JONES, Lieut.-Colonel, R.E.
R. J. NELSON, Captain, R.E.

Dublin, 1st August, 1846.

D.

DAM, PERMANENT.—*Vide* ~~vol. ii.~~ River Navigation –

DAM, TEMPORARY.*

Dam,—a bank or obstruction built across a river or stream, for the purpose of raising the level of the water on the upper side of it.

ion. There are many objects for the attainment of which it may be necessary thus to check the course of a stream, and gain a head of water: it may be requisite to turn it for a time into another channel; to inundate the ground in front of part of a military position; to make a portion of the stream unfordable; to secure depth sufficient to enable vessels of a given draft of water to navigate the stream; or to gain a power to be applied to mechanical purposes. The works for the attainment of the first three of these objects belong more particularly to the class which Officers may be called upon to execute in the course of a campaign; and the details here given refer entirely to works composed of such materials as may be expected to be within reach of an Officer on service.

Dams built for the purpose of inland navigation, or for that of securing a water power, may be considered as having a more permanent character, and will be treated of in the ~~(second volume)~~ of this work. (article on River Navigation)

f Site. The first consideration in forming a dam across a stream is the choice of a proper site: this must of course be decided with reference to the objects to be attained by the rise of water, but there are a few general rules to which attention should be paid.

In streams liable to sudden floods it would be advisable to carry the dam across the widest part of the stream, so as to allow ample space for the water to flow over, and thus to prevent any sudden and great rise above the dam; or it may even be advisable to carry the dam in an oblique line across the stream.

In rivers where much drift timber is likely to be brought down, the dam should be situated below a bend in the stream where an eddy is formed, by means of which the collection and removal of the timber will be facilitated.

The banks of the river or stream should be carefully examined with reference to the quality of the soil of which they are composed, and their power of acting as abutments to the dam.

When the site of the dam has been decided upon with reference to the principal objects which it is intended to answer, the necessary levels must be taken, and the height of the structure determined: upon this will depend in a great measure (when materials are plentiful) the plan to be adopted in forming the dam.

iction in ites. In shallow rivers, when the bottom is rock, a dam of the section shown in fig. 1 may be easily constructed of 10 or 12 feet in height. The sill (*a b*) is bolted down to the rock with fox-wedge bolts. The standard (*b c*) is mortised into this sill, and a brace (*a c*) is framed into the two, making thus a strong vertical frame. When the dam is high, a second brace may be inserted, and the horizontal distances between the frames diminished; but in general, 8 or 10 feet may be allowed as a fair distance between these frames from centre to centre. When the frames are securely fixed, a facing of logs, roughly squared on the upper and under sides, is laid in front of them, across the bed of the stream. These should be got as long as possible, and

* Chiefly by Capt. Denison, R.E., embodying some fragments by Lieut. Bainbrigge, R.E.

should break joint occasionally against a standard to which they should be sometimes pinned with a trenail, in order to prevent their moving.

When the water is intended to flow over this dam, the space between the frames in rear should be filled in with blocks of rough stone, well wedged together and laid in steps, so as to break the fall of water on the bed of the river in rear. If material of the proper quality cannot be found, or if the time will not allow of its being quarried and placed properly, this space may be filled in with earth and rubble, and logs being notched down upon the back braces of the frame, stout planking should be spiked over these logs, so as to present a smooth surface for the waste water to flow over, and to act as a protection to the stones, earth, &c., below. The front of the dam should also be filled in with earth, rubbish, &c.; and if the surface of the rock is so uneven as to prevent the front logs bearing fairly upon it, brushwood and fascines may be placed in front, so as in some measure to close the spaces between the rock and the logs.*

Construction when the ground is soft.

When the bed of the river is composed of sand, clay, or material too soft to resist for any length of time the action of the water, the plan shewn in fig. 2 may be advantageously adopted. This frame is composed of a sill, extending not only the width of the dam but also of the apron in rear, notched down and pinned to three or more sleepers, which are laid transversely to the stream, and sunk into the bed of the river. Into this sill the beam ($a\ b$) is framed at an angle of about 30° with the horizon, and supported in this position by the two struts ($b\,c$) ($d\,e$) at an angle of about 60°. These frames are placed at about 8 feet apart, and upon them are notched the horizontal beams which carry the planking with which both the up and down-stream sides of the dam are covered.

In order to prevent the water making its way under the dam, a row of plank piling (d) about 5 feet long and 4 inches thick should be driven in front of the upper sleeper, and a line of waling (f) upon this row of piling should be well spiked through the piles into the frame. In order to secure the work more completely against leakage, clay should be thrown in front of the sheet piling to a height of 1 or 2 feet. An apron (A), as shewn in figs. 2, 3, is a necessary addition to every dam constructed across a river when the bed has not sufficient tenacity to resist the action of the water. This may be composed of logs notched upon the sill pieces and covered with plank, or of rough logs, notched and pinned down upon the sleepers in close contact with each other: it should extend far enough below the dam to conduct the water away safely, and should have a row of sheet piling in rear, as shewn in fig. 3.

Construction when timber is plentiful.

When rough timber is plentiful, a dam, as shewn in figs. 3 and 4, may be easily and quickly constructed thus: two or three rows of rough sleepers are bedded across the stream, and upon these rough logs are notched and pinned at intervals of about 5 feet in the rear of the dam. Over one of these sleepers another transverse log is notched upon the first row of longitudinal timbers; and if the dam is a large one, perhaps a second transverse timber may be required. The second row of longitudinal timbers is notched upon the second row of transverse timbers, not exactly over the first row, but just so much clear of it as to allow of the end being notched and pinned upon the ground-way or sleeper at the upper side of the dam, close alongside of the first timber. Row after row of timber is thus placed, the dam constantly rising in rear by the thickness of a log for each course, while in front, all are brought down

* Occasionally, however, when the strata cross the bed, and particularly when they crop-out against the stream, great additional stability may be obtained by abutting the lower parts of the dam against the basset edges of the rock.—*Editors.*

and pinned to the ground-way. When the necessary height is obtained, the top row of longitudinal timber may be laid side by side in as close contact as possible, and the spaces made good with small fascines, bark, &c.; or rows of transverse logs may be placed at about 3 feet apart, and planks spiked to them. The rear of the dam appears as shewn in the sketch, figs. 3 and 4, of alternate rows of longitudinal and transverse timber, to which planking is spiked.

When timber is plentiful and the river is deep, a dam may be safely constructed to a great height of crib-work, that is, of a series of rough cases formed of whole timbers notched together at the crossings, as shewn in fig. 5. In framing a dam of this description, two logs are laid in a direction transverse to the stream, at the same distance apart as is intended for the width of the dam; upon these cross logs are notched at distances of 6 or 8 feet; other transverse timbers are notched upon these, and the dam is carried up in this way until it arrives at its intended height. Sometimes it may be advisable to divide the interior space into smaller compartments, by introducing more transverse timbers: during this, very little impediment has been offered to the stream, which flows through the interval between the logs.* When the crib-work is complete, the spaces between the cribs are filled with stone, if it can be procured; or if not, with fascines, earth, &c., and a mass of earth and rubbish is thrown into the river in front of the dam, so that by degrees a mass is accumulated sufficient to prevent leakage. This work is carried on simultaneously from both banks; and as the water-way is checked, so the stream rises above the dam, rushing through the central space left for its passage. The same process may be continued till the dam is completely closed; but as large quantities of earth, &c., would be washed away in attempting to close the opening between the logs in this centre bay, the best plan is to prepare a frame to receive a sort of gate made of logs, which can be dropped down from above, and which will close the opening sufficiently to prevent much waste of material taking place.†

Construction when timber is scarce.

When timber is scarce, fascines and hurdles may be used in the construction of dams. In Holland and Germany they are very commonly employed for this purpose. A course of large fascines is first laid, the length of the fascines being in the direction of the current, and each in as close contact as possible with its neighbours: upon this a second course is laid transversely, strong pickets are driven through these two courses to connect them together, and the heads of these pickets are wattled together, so as to make a kind of hurdle-work, which serves to connect the whole more completely into one mass: these layers of fascines are then continued in the same manner, each course being picketed to those below, and the pickets connected at top with hurdle-work until the dam has attained the proper height. Very large rivers with a great depth of water have been successfully dammed up and their courses changed by works constructed in this manner. Where the water is deep, gabions loaded with stones, square wicker baskets filled with stone, &c., have been used to form the foundation of the dam; and upon this a superstructure, as before described, has been raised.

The above are a few of the most simple and of the readiest modes of constructing dams; modifications may, of course, be made to any extent: two or more of these

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plans may be combined in the construction of a single dam,—as, for instance, the sides of a dam, when the water is shallow, may be made according to fig. 1, and the centre part with cribs, as in fig. 5.

Fig. 8, Plate I. Fig. 7, Plate II. The flank of the dam should be secured by being let into the bank and puddled in front, and the earth or rubbish which is thrown in front should be carried up the river against the bank to a greater distance than at other points.

As a general rule, the sides of a dam should be first constructed and the abutments made good: serious accidents have occurred from a neglect of this precaution. Should it be decided to raise the water so as to inundate the banks on each side, the embankment to prevent the water thus raised finding its way round the flanks of the dam, these flanks should be completed before the dam itself is closed. This embankment may be formed of earth: its section may be as in fig. 7, about 3 feet thick at the top, which should be about 1 foot above the highest water line; the up-stream slope at least 2 of base to 1 of height, the down-stream 1 base to 1 of height: in case the soil is light and porous, it will be necessary to excavate a trench in the line of the embankment about 2 feet into the ground, and about 2 feet wide; to puddle this well with clay, and to form a wall of the same through the centre of the embankment till above the water line, as in fig. 7, to render it water-tight. Where a current can act upon it, the base may be protected by stones and by planks, or fascines pinned down parallel to its direction. In all cases ample provision should be made for the passage of the waste water: when it is not allowed to pass over the dam, waste channels should be made, and the passage of the water through these regulated by sluices either self-acting (which is the safest plan), or worked by men. Great care must be taken that the action of the water through these sluices does not tear up and wash away the ground below to an extent to endanger the structure. Aprons (constructed as before described) must be laid in rear of the sluices, except when these are fixed upon rock, and must be carried down to a distance proportional to the body of water discharged, and to the fall, also taking into consideration the nature of the soil.* W. D.

DEFENCE OF BUILDINGS AND VILLAGES.†

OF PLACING BUILDINGS, &C., IN A STATE OF DEFENCE.

If a building forms part of a general line of defence, or is in the contour of the works round a town or village, the front and sides only may require being prepared for defence, for a force must not be shut up without a special object: if, on the contrary, it is an independent post, to be defended to the last, and is open to attack on all sides, every point must be equally looked to, and the means of retreat and of reinforcing it must be preserved, if considered necessary under the circumstances.

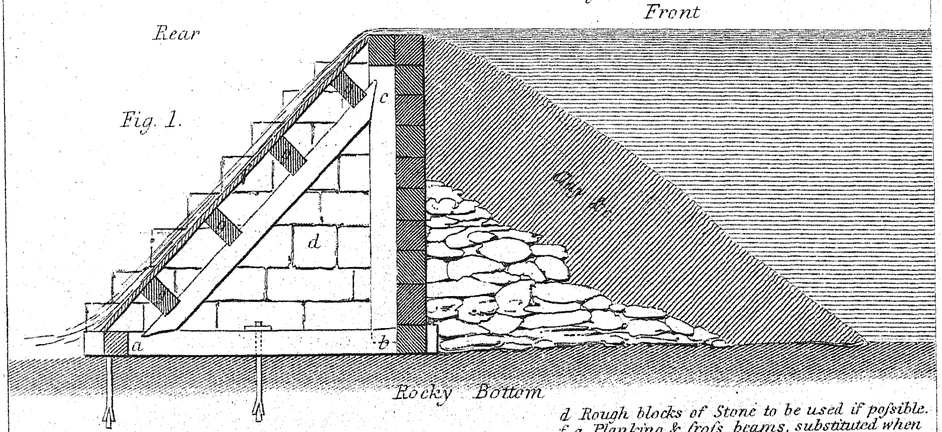
The great art of making a defensible post out of buildings, and the out-houses and walls that usually surround them, consists in selecting from the mass of objects before you what will answer the purpose, and sacrificing every thing else, making use of the materials to strengthen the part you wish to fortify. It is more difficult to state any precise rules for such proceedings than for laying out works in the field; for in one case you generally have a choice in the form of your intended works, and a better

* Bridges may often be converted into excellent temporary dams by blocking up the archway; taking care that the mass thus formed is sufficient to support the accumulated body of water, which must not be taken for granted with most bridges.—*Ed.*

† By Major Jebb, R.E.

Section of a Dam on a Rocky Soil.

Fig. 1.



d Rough blocks of Stone to be used if poſsible.
f g Planking & croſs beams, substituted when d cannot be obtained; the interior to be filled as in Fig. 2.

Section of a Dam in a Soft Soil.

Fig. 2.

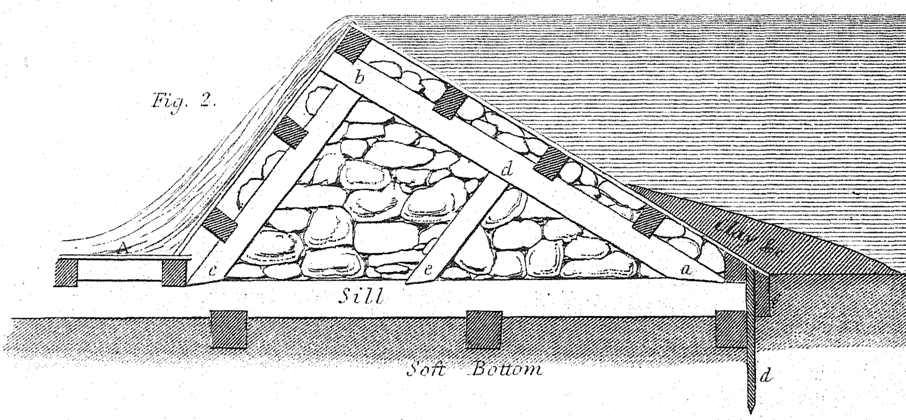
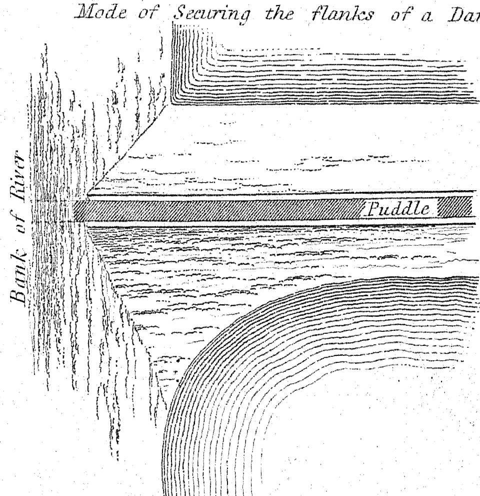


Fig. 8.
Mode of Securing the flanks of a Dam.



J.W. Lowry, sc.

Fig. 3
Section of a Dam on soft soil where Timber is plentiful.

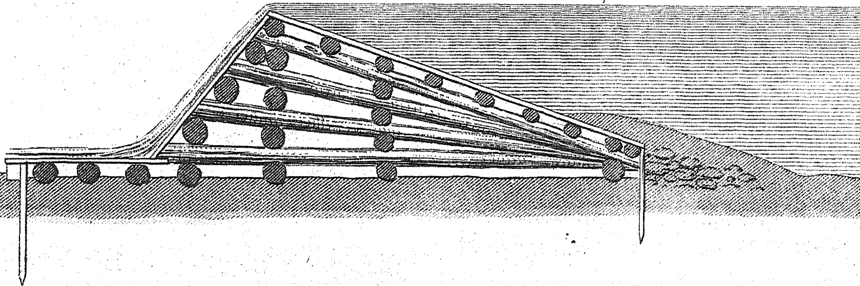


Fig. 4.
Elevation of the rear of Fig. 3. before being planked.

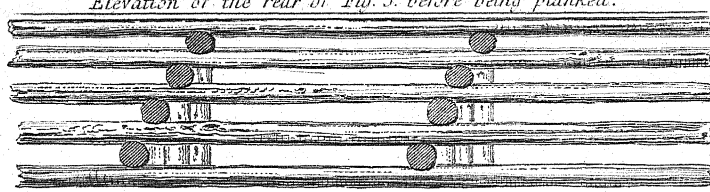


Fig. 5.
Plan of Fig. 6.

Figs. 5: 6.
Cribwork

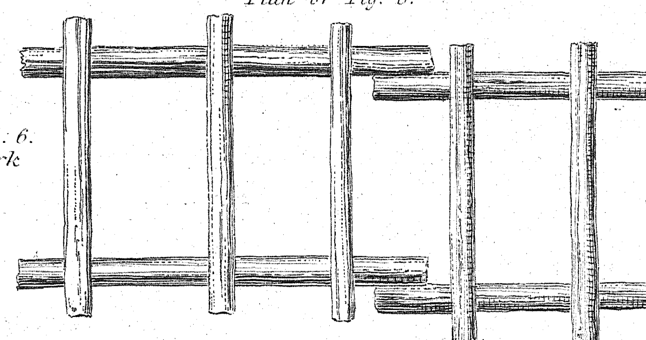


Fig. 6.
Transverse Section of Fig. 5.

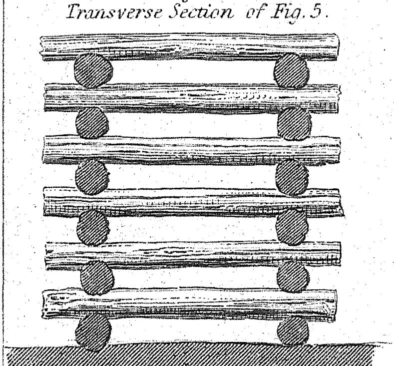
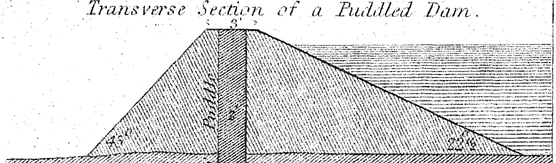


Fig. 7.
Transverse Section of a Puddled Dam.



John Weale, 59, High Holborn. 1846.
J. W. Lowry, fc.

opportunity of arranging what you have to execute under the direction of some general principles.

The principles of defence must be taken into consideration as far as they will apply, and if with a knowledge of these principles an Officer is practically acquainted with the means that are usually employed for strengthening such posts, a very little experience will enable him to arrange his plan, and set his men to work with a confident expectation that in a very few hours he will be able to enliven a peaceable domicile by converting it into a respectable fortress.

The objects now under consideration are churches, country houses, factories, prisons, or other substantial buildings; and as there is but little difference in the mode to be pursued for placing any of them in a state of defence, an explanation of the details applied to a single house will perhaps be sufficient to convey an idea on the subject.

What has before been said of the points requiring attention in the selection of a military post will be applicable if a choice is to be made among buildings: thus, a building proper for defensive purposes should possess some or all of the following requisites.

First. It should COMMAND all that surrounds it.

Second. Should be SUBSTANTIAL, and of a nature to furnish materials useful for placing it in a state of defence.

Third. Should be of an EXTENT PROPORTIONED TO THE NUMBER OF DEFENDERS, and only require the TIME AND MEANS which can be devoted to completing it.

Fourth. Should have walls and projections that mutually FLANK each other.

Fifth. Should be DIFFICULT OF ACCESS on the side exposed to attack, and yet have a SAFE RETREAT for the defenders.

Sixth. And be in a situation proper for fulfilling the object for which the detachment is to be posted.

A church will be found more usually to unite all these good properties than any other building.

It may be remarked, that though good strong walls are an advantage, yet their thickness should be limited to 2 or 3 feet, from the difficulty there would be in piercing loopholes; unless when they are likely to be battered by artillery, in which case the musketry must be confined to the windows, and the more solid the walls are, the better. It should also be remembered that brick houses and walls are preferable, on several accounts, to those built of stone; for when exposed to artillery, a round shot merely makes a small hole in the former, but stone is broken up in large masses, and dangerous splinters fly from it in all directions. It is much easier also to make loopholes through brick-work than through masonry. Wooden houses, or those made of plaster, are to be avoided, from the facility with which an enemy can set fire to them, and they are frequently not even musket-proof. Thatched houses are equally objectionable on account of fire, unless there is time to unroof them; and after all it must not be forgotten that earthen-works, when exposed to artillery, are to be preferred to houses, as far as affording security to the defenders is concerned. In seeking this security, however, it should be borne in mind that they are not so *defensible;* for troops cannot be run into in a house, but they are not exempt from such an intrusion in an earthen-work of the nature under discussion. The two together can be made to form a more respectable post than *either* can be made into singly, for the merits of both will be enhanced, and the defects be modified, by the union. A building is therefore at all times a capital base to go to work upon. The walls may be partially protected from cannon-shot by throwing up earthen parapets round it, and the house may 'reciprocate' by acting the part of a keep, and

afford the garrison a place of refuge, in which they may either defend themselves with advantage, or, if it 'suits their book,' resume the offensive, and drive the assailants out again.

An Officer will be able to make his selection at first sight, with reference to most of these points, but it requires a little more consideration to determine whether a building and its appliances are convertible into a post, of a size proportioned to the force under his command. The average number of men, however, proper for the defence of a house may be roughly estimated on some such data as the following. That in a lower story it might generally be proper to tell off one man for every 4 feet that the walls measured round the interior.* In the second story one man for every 6 feet, and in an attic or roof one man for every 8 feet. For example, if a house of three stories high were found on pacing it to measure 140 feet round the interior walls, the number of men for its defence on the above data would be determined thus:

Feet.

$\frac{140}{4}$ would give 35; which would be the number of men for the lower story.

$\frac{140}{6}$ would be about 23 men for the second floor.

$\frac{140}{8}$ would be 18 men for the attic.

Making a total of 76 men for the three stories; to which about one-sixth of the whole, say 14 men, should be added as a reserve, making altogether a garrison of 90 men. If there were out-buildings or walls in addition, the number of men required for their defence would be determined in a similar manner, by assuming certain data adapted to the circumstances as a guide in the calculation.

These numbers are not to be considered *definitive*, but merely to convey an idea on the subject; for if a detachment were much weaker in proportion to the extent, a vigorous defence might still be made, for the force might be concentrated where most required, as it is not a matter of course that a place will be attacked on all sides at once; or if a building were found so large that the disposable force would be too much disseminated, or if there were a want of materials and time for putting the *whole* of it in a state of defence, a *part* of it only might be occupied.

Should there exist any doubt about having sufficient time to complete all that might be wished, it would become matter for consideration what were the points which it would be of the greatest importance to secure first, so as to be in a condition to repel an *immediate* attack, because such points would naturally claim attention to the exclusion of all others.

In such a case, it might be well to employ as many men as could work without hindering each other by being too crowded:

Firstly. To collect materials and barricade the doors and windows on the ground-floor, to make loopholes in them, and level any obstruction outside that would give cover to the enemy, or materially facilitate the attack.

Secondly. To sink ditches opposite the doors on the outside, and arrange loopholes in the windows of the upper story. Plate I.

Thirdly. To make loopholes through the walls generally, attending first to the most exposed parts, and to break communications through all the party-walls and partitions.

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* Pacing round the outside of the house, and making an allowance for the thickness of the walls, would be the easiest way of determining the interior dimensions.

Fourthly. To place abattis or any feasible obstructions on the outside, and to improve the defence of the post by the construction of tambours, &c.

Fifthly. To place out-buildings and garden walls in a state of defence, and establish communications between them. To make arrangements, in the lower story especially, for defending one room or portion after another, so that partial possession only could be obtained on a sudden rush being made. These different works to be undertaken *in the order of their relative importance*, according to circumstances; and after securing the immediate object for which they were designed, they might remain to be improved upon if opportunity offered.

An endeavour will now be made to explain the mode of executing these works in the order in which they are mentioned.

COLLECTING MATERIALS.

The materials that will be found most useful in barricading the passages, doors, and windows, are boxes, casks, cart bodies, bricks, stones, cinders, dung, &c., and timber of any sort that comes to hand: if it cannot be found elsewhere on the premises, the roof and floors must be stripped to furnish what is required.

BARRICADING DOORS.

In the application of these materials, the boxes and casks filled with cinders or dung, and placed against the doors to a height of 6 feet, will prevent their being forced open, and loopholes may be made through the upper portions, which can be rendered musket-proof, to protect the men's heads: short lengths of timber piled one upon another to the same height, leaving a space between any two of them in a convenient situation for firing through, and their ends being secured in the side walls of a passage, or propped with upright pieces on the inside, will effect the same object; or a door may be loosely bricked up, leaving loopholes, &c.

If it is probable that artillery will be brought up for knocking away these barricades, and so forcing an entrance, a passage may be partially filled with dung or rubbish to the thickness of 8 or 10 feet, or thick beams of timber may be reared up on the outside of a door, and the interval filled with the same, or with earth, if more convenient.

A small hole, 3 feet square, may be left through an ordinary barricade for keeping up a communication with the exterior; but for effecting a retreat, or making sorties, it will be necessary to make a door musket-proof* by nailing on several additional thicknesses of plank, and arrange it so as to open as usual, or to contrive something on the spot which shall equally protect the men when firing through the loopholes, and yet be removeable at pleasure.

BARRICADING WINDOWS.

Windows do not require to be barricaded so strongly as doors, unless from their situation an entrance may easily be effected, or an escalade be attempted. The principal object is to screen and protect the defenders whilst giving their fire; any thing, therefore, that will fill up the window to a height of 6 feet from the floor, and that is musket-proof, will answer the purpose. Thus two or three rows of filled sand-bags laid in the sill of a window, (fig. 1,) or short lengths of timber, would do; or a carpet, a mattress, or blankets rolled up, would be ready expedients. Loopholes would in all cases be arranged, whatever materials were used. If time presses, and windows could not be blocked up, one means of obtaining *partial* security would be to hang a great coat or blanket across the lower part of them as a screen, and make the men fire beneath it, kneeling on the floor. The glass should be removed from windows

* Vide 'Barricade,' p. 126.

before an attack commences, as it is liable to injure the defenders when broken by musketry.

LEVELLING OBSTRUCTIONS OUTSIDE.

Any shrubberies, fences, or out-buildings, within musket-shot, which would favor an attack by affording cover to an enemy, and allowing him to approach unperceived, it is essential to get rid of as soon as possible. The trees should be felled, leaving the stumps of different heights, so as to encumber the ground, and the materials of walls, &c., must be spread about with the same view; but whatever is convertible for barricades should be carried to the house. The thatch from roofs, and any combustibles, should also be removed or destroyed.

Plate I.

DITCHES IN FRONT OF THE DOORS, &c.

As a means of preventing a door being forced, a ditch may be dug in front of it, about 7 feet wide and 5 feet deep: such a ditch also is necessary in front of the lower windows, if the loopholes cannot be conveniently made high enough from the outside to prevent an enemy reaching them, as would be done in managing matters for the Defence of Walls. These partial ditches may afterwards be converted into a continued ditch all round a house if opportunity offers, as it would contribute to the defence of the post. The floors may also be taken up on the inside, opposite the doors or windows open to attack.

LOOPHOLES.

Plate I. If the walls are not too thick, they may be pierced for loopholes, at every 3 feet, in the spaces between the windows, &c. (Fig. 1.) These loopholes can be knocked through with a crow-bar, or even a pickaxe: they should be just such a size as to enable you to see your friends, without being open to their remarks.

Two tier of these loopholes may be made if opportunity offers, and a temporary scaffolding of furniture, benches, casks, or ladders, &c., erected for firing from the upper ones: on the lower story a row of loopholes may be made close to the ground. The floor must, in this case, be partly removed, and a small excavation made between the beams for the convenience of making use of them. Just under the eaves of a roof there is generally a place where loopholes can be made with great facility, and a tile or slate knocked out here and there with a musket, will give other openings, from which an assailant may be well plied as he comes up. Plate II.

COMMUNICATIONS.

A clear communication must be made round the whole interior of the building, by breaking through all partitions that interfere with it; and for the same purpose, if houses stand in a row or street, the party-walls must be opened, so as to have free access from one end to the other. Means should likewise be at hand for closing these openings against an enemy, who may have obtained any partial possession. Holes may also be made in the upper floors to fire on the assailants, if they force the lower ones, and arrangements made for blocking up the staircases, with some such expedient as a tree, prepared in the same manner as for an abattis, or by having a rough palisade gate placed across. Balconies may be covered or filled up in front with timber or sand-bags, and made use of to fire from downwards. Fig. 2. (Vide Abattis, p. 32).

ABATTIS.

The partial levelling of any object on the outside, that would give concealment to an enemy, and favor an attack, is supposed to have been already attended to; but if time admits, after the loopholes, &c., are completed, this system must be extended

and perfected, and the formation of a more regular abattis should be commenced, and any other obstruction added that opportunity permits. The best distance for such obstructions, if they are continuous and cannot be turned, is within 20 or 30 yards of a work, or even less, so that every shot may tell whilst the assailants are detained in forcing a passage through them.

TAMBOURS.

If the building that has been selected has no porches, wings, or projecting portions from which flank defence can be obtained, it will be advisable to construct something of a temporary nature to afford it.

Stockade-work offers a ready means of effecting this object: it may be disposed in the form of a triangle, projecting 8 or 10 feet in front of a door or window (fig. 4), planted in the manner, and with the precautions of having the loopholes high enough. A small hole should be left in the barricade of the door or window to communicate with the interior. Three or four loopholes on each face of the projection, cut between the timbers, will be found very useful in the defence. These contrivances are usually termed tambours, and if constructed at the angle of a building, will flank two sides of it. (Fig. 3.)

OUT-BUILDINGS AND WALLS.

When the defences of the main building are in a state of forwardness, any out-buildings or walls which have been found too solid to be levelled at the moment, or which have been preserved for the chance of having time to fortify them, and thus to increase the strength of the post, must be looked to. They may be placed in a state of defence by the means already described, and separate communications should be established between them and the principal building by a trench, or a line of stockade-work, and by breaking through the walls when necessary. In this way a post may be enlarged in any required proportion, by turning all objects that present themselves, such as out-buildings, sheds, walls, hedges, ponds, &c., to the best account; first taking the precaution to secure what is absolutely necessary for *immediate* protection, and for placing it in a state to be defended on the shortest notice.

An exterior wall or fence, tolerably close to a house and parallel to it, may be retained for the purposes of defence, without the danger of affording cover, and thus facilitating an attack, by throwing up a slope of earth on the outside of it, or planting an abattis in the same situation (fig. 5). An enemy would thus remain completely exposed, and it would be worse than useless to him.

If a post of the description under consideration were composed of two or more buildings, and it were to be left to itself, and were open to attack on all sides, the stockades or trenches, forming the communications between them, would obviously require to be so arranged as to afford cover, and the means of resistance *on both sides.* This would be effected by merely making them *double,* as shewn in figs. 5 and 7; but for greater security, the exterior of such communications should be laid under fire from the buildings at their extremities.

In arranging the defences of such posts, it is an essential point to make each portion of them so far independent of the others, that if any one part, such as a building for instance, be taken, it shall not compromise the safety of the remainder, or materially impair the defence they will make by themselves; so that whilst free communications are essential in most cases to a vigorous defence, the means must be at hand for instantly cutting them off by some such expedients as would be afforded by a loopholed musket-proof door, or rough gates, or by letting fall a tree prepared as for an abattis, and which till wanted might be reared on its end in the situation required; having previously secured the means of bringing a close fire upon it.

It is incredible what a defence may be made in a substantial building, if it has been properly prepared, and the right sort of people have been put into it. The Siege of Saragossa, in 1809, affords a proof of how much may be done in defending streets and houses. The French were reduced to the delay of an attack, *secundem artem*, and no impression was made but by the regular means of artillery and mines. It is to be recollected, however, that the houses could not be set on fire, and the walls were of extraordinary thickness.

Plates III. & IV. Figs. 8 and 9 are given as examples of a country-house and out-buildings, which have been prepared for defence in the manner described.

DEFENCE OF VILLAGES.

Though the placing a village in a state of defence argues that larger forces, and Officers of higher rank and more experience are engaged, than has hitherto been contemplated in the smaller posts that have been discussed in this article, yet, in cases of emergency, much responsibility may still devolve on a young Officer in executing, and in some measure planning portions of the work: the subject therefore will be briefly noticed, though the details already entered into embrace much of the information which would enable him to make himself useful on such an occasion.

As a village is only the extension of a smaller post of the same nature, the general requisites adverted to in the preceding, when treating of such posts, should be looked for in determining whether or no it is favorable for defensive purposes, and whether it offers such facilities for executing the necessary works as that they can be completed in the time that can be devoted to them.

Thus a village should not be commanded;—it should furnish materials proper for its defence, and be of a nature not easily set on fire;—of a size proportioned to the force designed to occupy it;—should be difficult of access, &c. In addition to which there should be some substantial buildings near the exterior, to be converted into strong salient points of the general line. And in most cases a church or large building in the interior, to serve as a keep, would be a desideratum. There should likewise be a facility for forming a connected line all round, or on the front and flanks, if they only were to be fortified. If it were situated on a height, some of the sides of which were inaccessible, or if it were partially skirted by a river or marsh, so much the better; it would be more easily rendered defensible.

An idea may be formed of the extent the works should have in reference to the disposable force, by making a rough estimate on the principles advanced, bearing in mind that they will admit of considerable latitude either way.

Villages may be required to be intrenched under a variety of circumstances, but as far as the works themselves are concerned, two cases only require consideration, viz., when they are left *open in the rear*, and when they are *enclosed all round*.

Under the first consideration;—if a village is to be held as an advanced post, or forms part of a general line, in front of an army, and it can receive instant support when attacked, it will generally be left *open in the rear*, and only be strengthened in front. To effect this, the first attention of an Officer, after determining his general plan on the principles already laid down, would be directed to the readiest means of stopping up all the streets, roads, and lanes on the front and flanks of the exposed side, with such temporary obstructions as could be most expeditiously formed.

Men would be detached to bring to the spot selected whatever materials would assist in the work, such as waggons, carts, ploughs, harrows, trees, gates, rows of paling, furniture, chains, ropes, &c. With these there would be no difficulty in

creating obstructions in a very little time, that would interfere with the visits of cavalry, and break the order of infantry, and thus offer impediments to an immediate attack. They should be placed in those situations where they would afterwards be of some use, either as obstacles in front of other works proposed to be executed, or in the principal line itself, and therefore to be improved upon; for, if possible, NO LABOUR SHOULD BE THROWN AWAY.

Whilst these works were in progress, an Officer would have more leisure to examine his whole post in detail, in doing which he would find it convenient to make a memorandum of the number of men that could be employed to advantage, and the probable time it would require to complete each of the works he proposes for its defence, so as to suit them to his means. These being afterwards confided in distinct portions to the active superintendence of intelligent young Officers, would insure their being done in less time than were he to attempt *ubiquity*, in looking after them all himself.

In arranging his general plan, he will have selected, as far as circumstances have favored him, some good substantial buildings, not exceeding the effective range of a musket, say 150 or 200 yards apart, for the most prominent or salient points of his line, which will be prepared for defence, as explained in the foregoing pages; or he will have decided on occupying those points with the best breastworks or stockades he can make in the time; and availing himself of all buildings, hedges, ditches, walls, or inequalities that lie between them, he would proceed to make arrangements for connecting them by breastworks, trenches, stockades, or some other of the means already described, and on the principles laid down respecting flank defence, and giving a good fire to the front. His working parties would be distributed accordingly, and it would be his constant endeavour to obtain the best cover, and to create the greatest obstructions, with the least possible labour. No exertion should be spared until the enclosure were perfect, and in a state to be defended; all hands should be employed night and day, if necessary, in alternate reliefs, and every arrangement should be made with this view: such points as required the greatest attention might then be progressively improved upon.

All the streets and roads open to attack should be shut up by good barricades constructed in rear of the temporary obstructions that have been created. These barricades may be made, if time admits, by sinking a ditch 7 or 8 feet deep, and forming the earth into a substantial breastwork (fig. 9), planting palisades, &c., if opportunity offers. Or if not exposed to artillery fire, stockade-work would be very effective; but if time presses, casks, boxes, or cart bodies, arranged in order and filled with earth, stones, dung, or cinders, would be a ready expedient. Bales of goods, hogsheads of sugar, sacks of malt, or even the rolls of cloth out of a tailor's shop, would be very convertible to such like purposes if they came to hand.

The mass should be raised 6 or 7 feet high, and a banquette or step be arranged for firing over it. The access should be as much obstructed as possible, and above all, every house in the neighbourhood should be loopholed, so as to give a good flanking fire over the ground in their front.

If several barricades are made in a street to be disputed in succession, the means of retreat through them must be preserved. This may be effected by disposing the lines as already explained, by which the passages would be readily closed and defended; and a communication should be made from house to house on each side the street, for firing on an advancing column.

In front of his post, it would be an object to destroy all houses within range of musketry,—to level all fences, and fill up all ditches, &c., that ran *parallel* to the

general line he had taken up within that distance, so that an enemy might find no cover whatever: such fences and obstructions, however, as ran *perpendicular* to his post, and that could be seen from it on both sides, might remain, as they would interfere with the flank movements of an attacking force, and embarrass his approach. Within the line of works, on the contrary, all fences and obstructions that are *perpendicular* to the line, and interfere with a free communication from right to left, should be cut away. Those that are *parallel* should be preserved, as affording protection to a retreat and further means of defence, if the outer line were forced. It is very important to have a second or even a third line of defence prepared, if the position of the buildings and localities admit of such an arrangement, so that if troops are driven from one line by a superior force, they may find another and another in their rear, all ready for occupation.

Such posts as these, when situated in a plain before the front of an army, or as a point of *appui* for one of its wings, have a very important part to play. But to enable an inferior force to derive the greatest possible advantage from them, they should not only be strengthened in themselves, but every obstruction in rear of them should be levelled, so that there may be facility for the movement of all arms for their immediate support when attacked. If there are fences or walls in existence which cannot be cleared away, good broad roads should be made through them: on the other hand, if a force in connection with such a post is on equal terms with an enemy, so that the offensive may be taken up, and a forward movement made, as opportunity offers, it would be injudicious to have obstructions in front, which might in that case be in the way. Probabilities and circumstances alone can decide what is best to be done.

Under the second consideration, if a village were to be occupied as an independent post, to be defended to the last, energy and intelligence must be drawn upon to the utmost, to place it in the best possible state. The details of execution will be similar to those already explained, as well as the general principles which regulate the whole; but it must be *enclosed all round* with an outer line, and if possible some strong building, such as a church or jail, must be looked up and put in a state of defence, and supplied with provisions, ammunition, &c., to which, as a citadel or keep, the defenders may retire, and there fight the battle over again, with a better chance of success, if driven in by an overwhelming force.

This keep should be centrally situated, in a position covered from the enemy's artillery, and commanding the principal roads or streets. It should be of a nature not easily set on fire, and should have good and assured communications with all the outworks. Advantage must be taken of any walls and out-buildings surrounding whatever has been selected as a keep; and they should be converted into outworks for strengthening it as an independent post. These outworks are the more necessary, as besides the additional strength they will impart, they will be found of essential service in securing a retreat into it; for a reserve quietly occupying them ought to command considerable respect from an enemy, however hotly he might be in pursuit.

If suitable buildings were to be found, and there were men enough to defend them, several such keeps might be prepared; and on the contrary, if a village should be of too great an extent for the force thrown into it, a portion of it only might be strengthened, and the remainder be separated or destroyed; or the defence might be confined to some principal building. Plate I. is taken from sketches inserted in some Instructions published by the French Imperial Minister of War in 1814.* In this sketch the existing buildings and streets, &c., that have been taken advantage of, for

* Slightly modified in correction of some defects.

defensive purposes, will be easily distinguished from the new works, which it has been necessary to add for a more effectual application of the principles adverted to. On one side the village is covered by a river and an inundation, which of themselves present a barrier, and the bridges which communicate with the country are shut up with temporary works of the nature explained, so as to render it tolerably secure against an attack from that quarter.

On the other side the river the buildings do not appear to have been disposed very favorably for the defence, which has made it necessary to construct a variety of new works. These have been laid out so as to give fire to the front and reciprocal flank defence; they consist of stockades, and earthen breastworks with ditches in front of them. The streets, it will be observed, are all barricaded. Communications are also broken through all the houses in the contour close to the parapets. The principal buildings, probably a church and a prison, will be easily recognised; they have been converted into keeps, and appear well situated for the purpose of supporting, and if necessary, of receiving or covering the retreat of the defenders of those portions of the outer lines which are contiguous to them.

Such works as are here treated of are not supposed to be proof against round shot, which is a defect that must be charged against the want of time to make them so: if, however, troops are secured from observation, and from the immediate effects of case-shot, bullets, sabres, and bayonets, which are far more destructive, and they are besides placed in an attitude to resist a superior enemy, and above all to *gain time*, it will be admitted that a great object has been attained at a trifling expense of labour.

Numerous instances might be adduced where posts, fortified in the greatest haste, have offered a more protracted and effectual resistance than more regular and more imposing works have done; which may partly be attributed to measures of evident necessity being adopted, which might have eluded previous calculation; and to an enemy generally coming upon them unprepared with the requisite means for their attack.

It will ever be found that a man of energy and resource will do more for himself in such a case of emergency than a man of rule; and it will be encouraging to a young Officer to reflect, that zeal and intelligence, aided by a very little practical knowledge, will go far to effect all that could be expected from scientific acquirement and greater experience.

GUARDING AND DEFENDING AN INTRENCHED VILLAGE.

The general disposition of a force for the defence of an intrenched village would be influenced by the principles adverted to, as far as the difference of locality and circumstances will permit of their application; and as the chief defensive works would usually consist of a combination of buildings and intrenchments, &c., which have been separately under consideration in the preceding pages, it will be needless again to enter into the *local* disposition of the defenders of such works, or the means which they are to resort to for resisting an attack. A village, however, may be of considerable extent, calling for additional precautions and defensive measures, corresponding to its importance as a military post: a few further remarks on the subject may therefore not be superfluous, as they may at least serve to combine, under one general plan, the separate defences of such detached portions as would be under the superintendence of individual Officers, and thus render each part more intelligible.

To guard against a surprise, and to be in readiness to repel an attack at any moment, and in any quarter, are objects demanding equal attention, and are the main spring and basis of all defensive measures. The latter, by judicious internal arrangements, in occupying the different works to advantage,—posting the pickets, reserve,

and support, so as to enable them to do their duties with decision and effect,—appointing convenient situations for assembly on the first alarm,—judiciously quartering the troops, &c.

In making these preliminary arrangements for the defence, a Commander would never lose sight of the great importance of getting every man to his post in the least possible time; and when he had ascertained by false alarms, or other means, what he could trust to in that respect, his next care would be to take such steps as would at least insure sufficient notice of the approach of an enemy, to enable him to dispose his force without hurry, for giving him a warm reception. For instance, it might require half an hour to do this leisurely, and he would therefore, on this supposition, so distribute his outposts, &c., as to feel secure of having the time to himself, after the first alarm was given, and before an attack could possibly be made. If he fails in having sufficient notice to do this, it is ten to one he is beat, for the best measures will be of little avail if they cannot be carried into full effect. It will be needless to harass troops by multiplying outposts so as to secure earlier intelligence than is required; but still it will be an error on the right side to take twenty precautions too many, rather than to neglect a single one. In making his dispositions, therefore, he would endeavour to steer a middle course between two extremes; on the one hand, if troops are overworked in preparing for an attack, and guarding against a surprise, they are thrown out of condition for resisting it when made,—on the other, if all due precautions are not taken for first strengthening the post, and then guarding it, they risk the loss of all their labour in being exposed to a sudden attack, at a time when they are in no form for opposing adequate resistance.

In the distribution of the defenders, too, there are extremes to be avoided; for instance,—if all the parapets and works are manned without regard to the requisite force which should be in reserve for giving support, though the greater number formed for opposing a first shock might lessen the danger of being upset by it, yet a line cannot stand up for any length of time against a column, that from circumstances can be brought into contact with it; and when once it is forced at two or three points, the game is pretty nearly up, unless there is something fresh to go to work with. The opposite defect would be in giving undue strength to the reserve at the expense of the parapets, which, from being feebly defended, would not then offer the resistance they ought to oppose. Another such a passage to steer between a Scylla and a Charybdis, and another to that, might be added if these little principles were pursued further; but we may safely trust to common sense suggesting more on the spot, under the ever-varying circumstances that arise on service, than the *memory* can supply,—provided that the *simple principles* and *essentials* of the subject have made that impression on the mind, which has secured their *saliency*. If they are *at home* when wanted, there is a natural tendency in minor matters to fall into their places and come right of themselves, and we will therefore leave the rough outline as it is.

The proportion of the disposable force to be retained in hand for the reserve, would be governed by circumstances, depending on the number of assailable points, and the calls that might be expected to be made upon it for assistance,—perhaps from one-fourth to one-sixth of the whole would not be far off the mark. The remainder would be subdivided for a variety of duties, such as a garrison for each separate house that had been strengthened, and one for the keep,—defenders for the intrenchments, breastworks, and stockades,—pickets, guards, &c.

A strong reserve picket should be mounted at the rallying point of the reserve, which should be near the centre of the village, in some open place having free communication to all the defences. Another picket would be in the keep, and, according

to circumstances, others might be required at different points. An outlying picket or two would be equally necessary in commanding situations beyond the works, and a communication between all of them should be kept up by a chain of sentries, or frequent patrolling. If cavalry form part of the force, some of the outpost duties during the day-time should be intrusted to them, as they can patrol to a greater distance to see what is going on, and obtain information. In the evening they would be replaced by infantry, but if the posts were distant, a few cavalry patrols should be attached, to assist in keeping up the communication, or to gallop in with intelligence. The pickets would of course be accoutred and ready to stand to their arms at an instant's warning, and those for the immediate defence of any distinct portion of the works, such as intrenchments or barricades, should either be hutted or encamped close to the spot, or lodged in the nearest building, if one were found conveniently situated for the purpose: this is essential, for an enemy, if unopposed for even a few minutes, will surmount without difficulty such obstacles as are usually met with in the temporary works that have been treated of.

Every Commanding Officer of a regiment should have a steady non-commissioned officer of each company to sleep within hail of him every night,—one who is perfectly acquainted with the quarters of every officer and non-commissioned officer in his company; so that at any instant, orders might be conveyed with the utmost promptitude to any part of the corps, however much it might be distributed. And on the same principle, every Officer in command of a company which was detached, should retain the means of readily communicating orders.

The support too, should be close at hand in the nearest houses, and they should have a hint that there is no necessity for being *shy* about breaking out fresh doors, or doing any thing else that may make their communications more *direct* or *convenient*. On these occasions it should always be borne in mind that a *straight* road is the shortest, and if it is a *wide* one, so much the better, provided it is not one that an enemy can avail himself of. In more permanent works, there is not this extreme necessity for having the defenders of them as it were constantly under arms to repel an attack; for if a sharp look-out is kept, the obstacles presented by deep and wide ditches, stout palisading, &c., will of themselves consume as much time of the assailants as will enable the defenders to repair to their posts, even if it was at rather shorter notice than might be agreeable; but here it is obviously a matter of paramount necessity.

These precautions having been taken for guarding a village against a surprise, and for immediate defence, and the remainder of the force being apportioned according to circumstances for occupying the different works and buildings, it would become an object to quarter them all as close as might be to the scene of their exertions, that there should be no unnecessary delay in getting them to their posts. Each separate detachment should have a sentry to stir them up on the first alarm, and when circumstances required it, they should all sleep on their arms, or they will not make so quick 'a turn out' of it as may be wanted. Every precaution should be multiplied by 2, when the nights are dark and tempestuous, as that is 'the time o' day' for a surprise. During the winter too, when men cannot be so much exposed under arms, and human nature is prone to look for scraps of creature comfort, under the lee of any thing that will protect them from a keen North-Easter, the attention of Officers cannot be too much directed to enforce these duties, and to see that every body who ought to be on the alert is so. A single sentry standing with his back up behind a tree or under a parapet, instead of snuffing the morning air with his face the other way, might cause the sacrifice of the whole post. Indeed, when all has been done that the most zealous watchfulness could dictate, a Commander and most of his

people should still 'sleep with one eye open' if the enemy is within a march of him. The best measures that can be devised are not infallible, even by day, and to prevent being *taken short* at night, it is safest to consider that a column of attack, with grenadier caps and mustachios, all teeth, hair and steel, might rise up out of the bowels of the earth, or drop from the clouds, close in front of the defences, at any moment. If you are prepared for such emergencies as these, you may go to bed with the conviction that you are ready for him; and let an enemy then do his worst, you will at least have the satisfaction of not having been outwitted.

Among other things, it is most essential that every officer and soldier should be thoroughly instructed in the nature of the work he had to defend, and the duties he had to perform, in all the exigencies which prudence could foresee. They should also be perfectly acquainted with every street, alley, or foot-path by which they might have to move, so that on the first alarm, even if the night were as dark as pitch, and they had not time to give themselves a shake by way of toilet, still there would be no confusion or mistake in repairing to their respective alarm posts, and afterwards being posted for the defence according to whatever orders might have been given.

If it should seem desirable, and the garrison is sufficiently strong to afford to make a sortie, it is essential that it should be well timed and vigorously executed, and be in sufficient force to make some impression, either as a diversion in favor of the defenders of the parapet, or to drive the assailants back beyond the obstacles they may have already surmounted. The party may be selected from the reserve and the defenders of the interior of the village, leaving the parapets fully manned, as they ought to be. The sorties should be drawn up at the points by which they are to go out, and at the critical moment when the speed of the assailants has been first checked by the opposition they might meet with in front, a furious onset with the bayonet should be made on one or both flanks; and when the object was effected, the troops should retire within the works again, as fast as they came out. The firing from the defences would cease whilst they were engaged, and be resumed with the utmost vigour the moment the front was clear again. Arrangements should also be made for covering their retreat, by being in readiness on the neighbouring parapets to open a heavy fire the instant it was required.

During an attack, the reserve should be within ear-shot of the Commander of the post, or his bugle, as it would be by the instantaneous application of this part of the force at the right moment, that his hopes of remedying any disaster would mainly depend.

Before he determines to strike a decisive blow with so important a body, a Commander should assure himself that the attack is a *real* one, and that the defenders and their support have been unable to deal with it; and when he has made up his mind, he should bring forward the whole or a portion of the force to the spot, as might seem expedient, and make the most impetuous attack possible; for if the reserve is checked, and the original defenders of the work are still in disorder, it will be up-hill work to regain the ascendancy. The whole force should rally, and be re-formed at some little distance, and a desperate attack be directed on the front and flanks of the assailants, who we may reasonably conclude would not be in the very best order for receiving it; and if it were successful, and they were fairly driven back, all would be right again. The reserve would regain its post, the defenders and the support would do the same, and every thing would then be ready to play the rubber out.

If, however, a Commander sees that he is overmatched, either by the combinations or numbers of his enemy, it remains for him to conform to circumstances, and shew that prudence is the better part of valour.

It is stated that villages may be intrenched under different circumstances, the chief

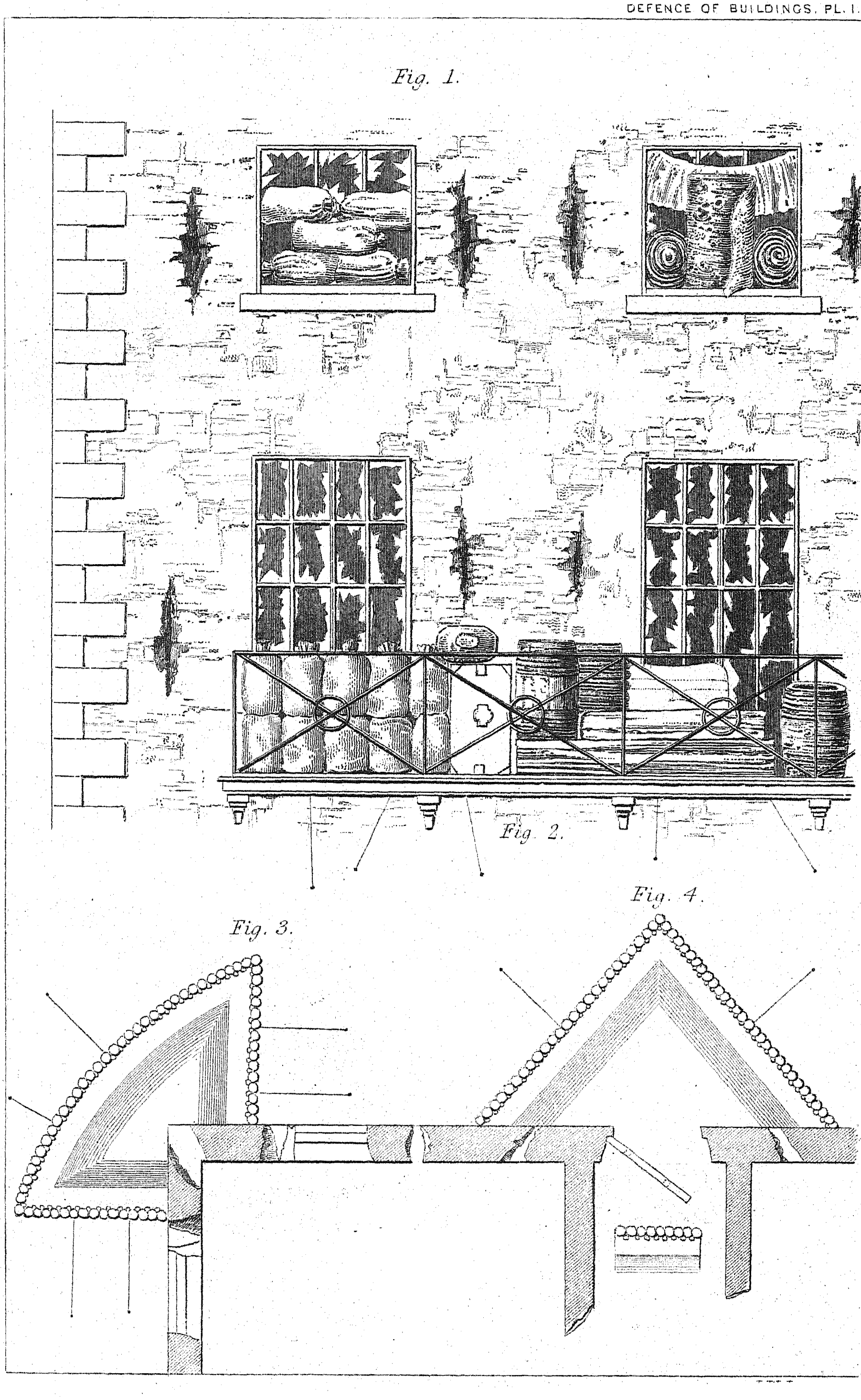


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.

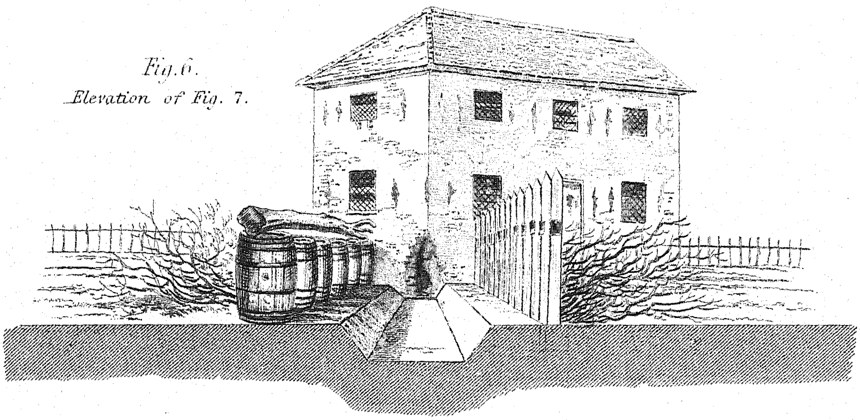


Fig. 6.
Elevation of Fig. 7.

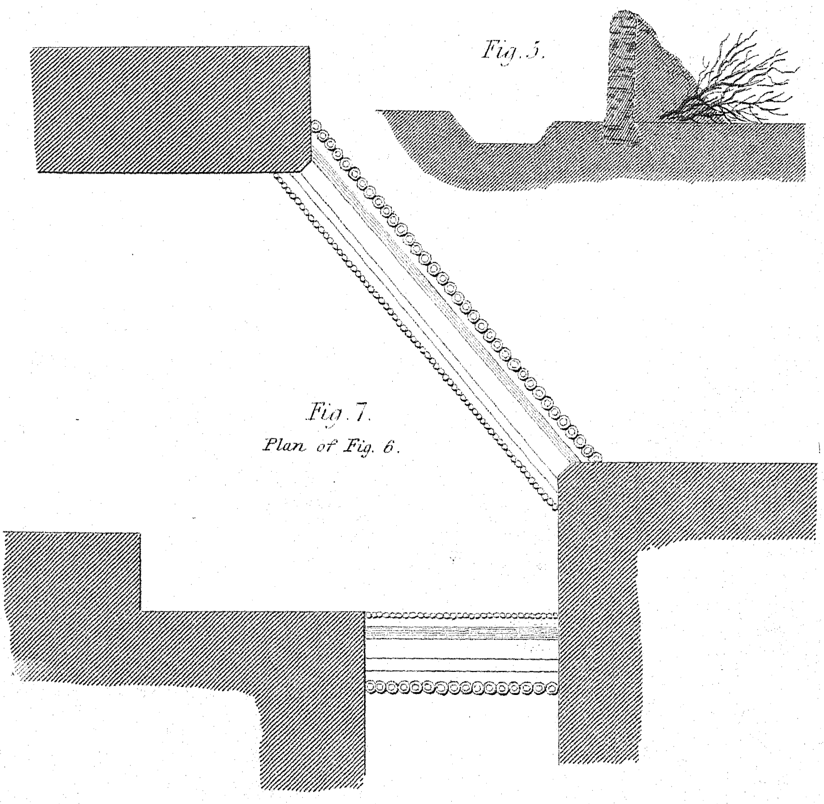


Fig. 5.

Fig. 7.
Plan of Fig. 6.

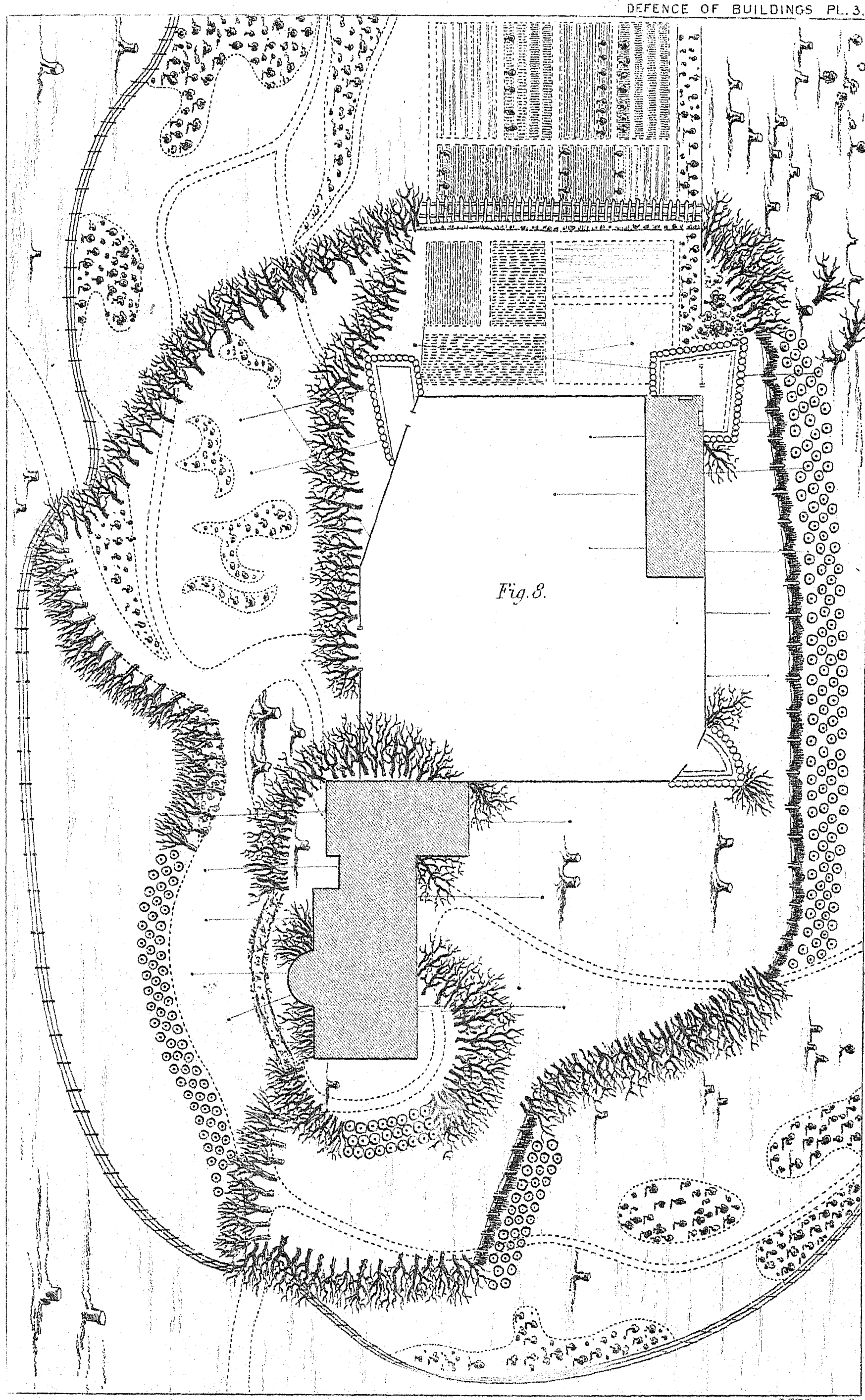


Fig. 8.

J. W. Lowry Sc.

John Weale 59, High Holborn, 1846.

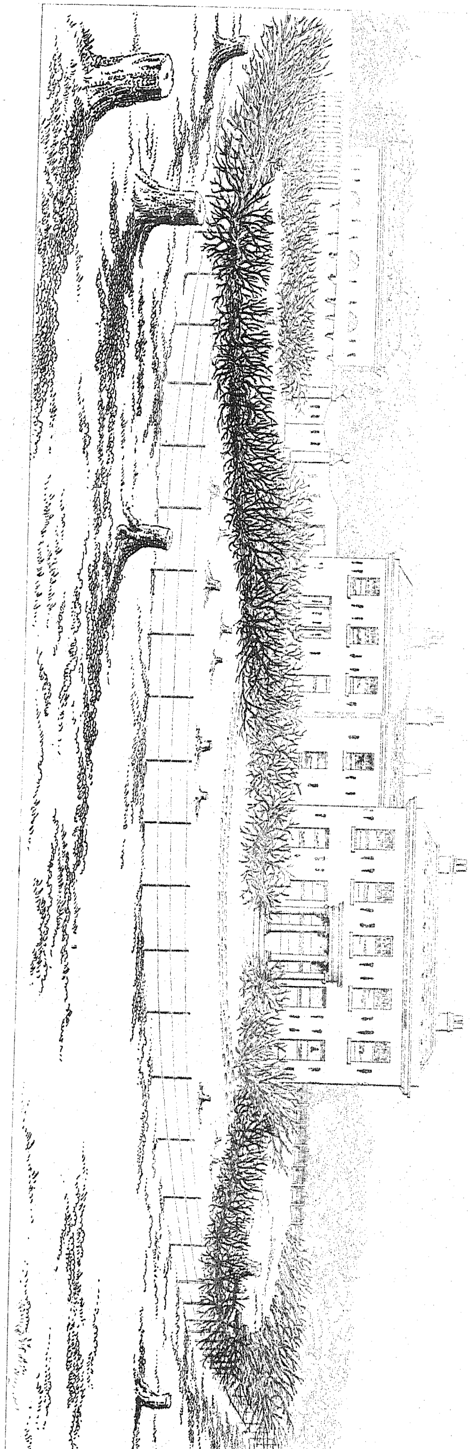
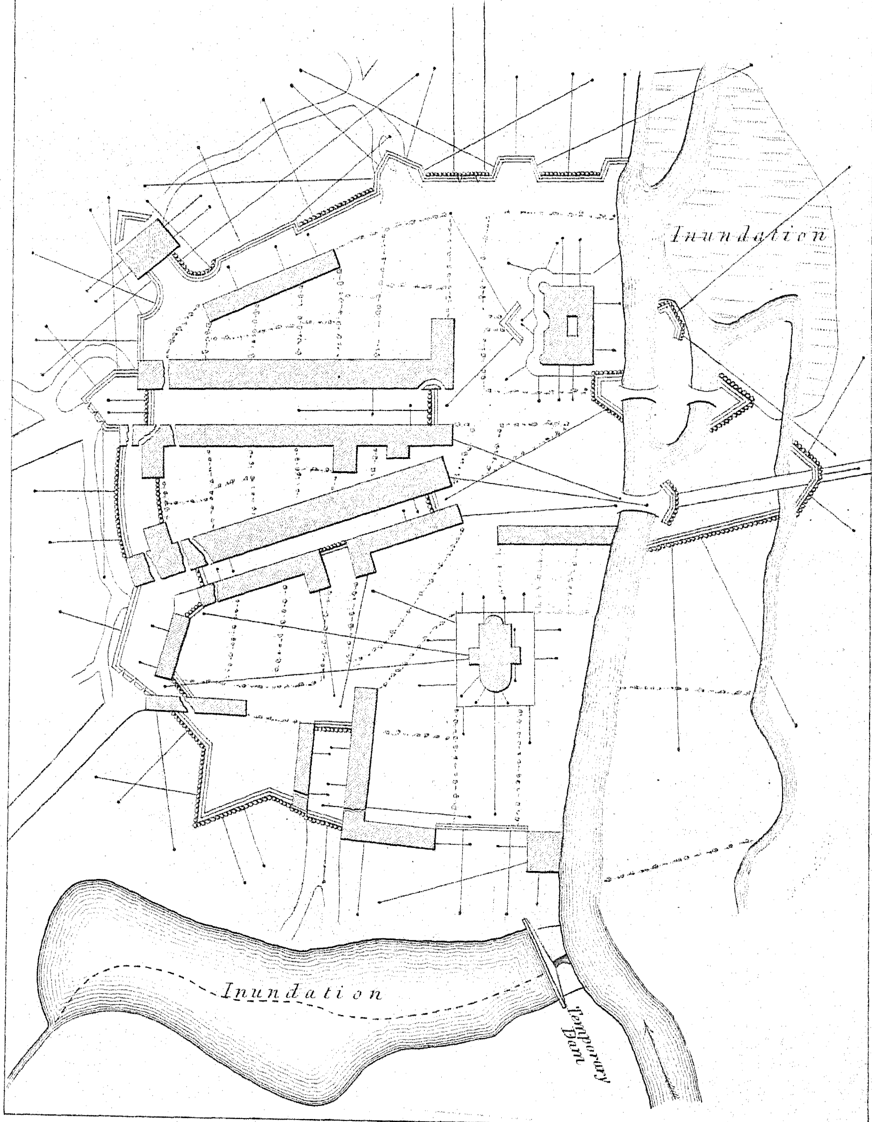


Fig. 9.

J.W. Lowry fc.

DEFENCE OF VILLAGES.



J. W. Lowry sc.

John Weale 59 High Holborn 1843.

of which are,—whether the force defending them is to be supported from the flanks or rear during an attack, or whether the post is to be considered independent of other operations, and therefore to be defended to the last by the troops thrown into it. In the former case, the communication with the rear and on the flanks, and the means of holding the ground by a succession of defensive lines, would have been previously arranged, which would give the supporting troops the opportunity of acting with effect, whilst the original force was re-forming. In the latter, a keep would have been indispensable, and the reserve would protect the retreat of the different detachments from the more open works of the contour into this stronghold.

Much however would have to be done on both sides before a retreat to the keep or any where else would be thought of; and as *much* cannot be done without an expenditure of *time* to do it in, the object of defending the post at all might still be fulfilled, whatever the issue of the combat might be; for in all combined operations we may say with a French author, *'Que le but de l'art defensif est de gagner du temps.'*

More important ends than saving a little time are however frequently gained at the trifling cost of taking the trouble to strengthen a post; for the determined attitude which all the troops affected by the operation are enabled to assume, from feeling a proper confidence in the resources which may be acquired by these means, either for defending themselves or for repelling an attack, may have the effect of warding off a threatened blow altogether. There is certainly something in the bristling look of an abattis, and the mischievous aspect of a wall or building full of loopholes, enlivened by an occasional appearance of a cap or a bayonet, that is more calculated to induce a little reflection than when dangers are more obviously inviting.

DEFENSIVE ELEMENTS* obtained from the local vegetation of every climate: scientific plantation being inexpensive, easily kept in repair, stronger with age, and then less destructible by hostile missiles than regular revetted works.

> "Nervii quo . . . . . . impedirent, teneris arboribus incisis atque inflexis, crebrisque in latitudinem ramis enatis et rubis sentibusque interjectis, effecerant ut instar *muri* hæ sepes munimenta præberent. Quo non modo *non intrari* sed ne perspici quidem possit."—*Cæs. de B. G.* lib. ii.

Officers charged with the defence of a frontier, an island, or a colony, are often unable to carry their projects of fortification into effect on account of the enormous expense they demand when the system is sufficiently enlarged to be really effective. Moreover, Engineers find themselves posted in regions where the materials required for the due execution of their purposes are rare, expensive, or inaccessible, and where the scientific systems, primarily invented for the conditions of European warfare alone, are little applicable; or if they are within this sphere, they may have to submit projects, which, however much they may be appreciated for their importance and utility, are nevertheless inadmissible, because under existing systems of national defence, the resources of a kingdom are often scarcely, or not at all, adequate to the expenditure of construction and repairs.

It becomes, therefore, desirable with the departments in charge of this great branch of the Service, to devise means both on the great and on the smaller scales for home and for distant regions; which, while they maintain the most approved principles of per-

* By Lieut.-Colonel Hamilton Smith, K.H.

manent defence in their integrity, render them nevertheless available in all places, by such modifications as the nature of the soil or the climate will admit and the elements accessible for the purpose offer for employment. In all climates, the resources of mountain, hill, rock, ravine, sea, lakes, rivers, and marshes occur; but the best systematic methods for adapting them to defence are not the object of these remarks: they are thoroughly understood by the scientific corps in every Service. Now the use of a method applicable to permanent fortification,—one entailing but a comparatively trifling expense,—kept up in a perfect condition with only the proper supervision of a few well instructed men, and withal, one under such supervision becoming stronger and stronger with the increase of years,—may be found in the botanical resources of every region more or less fit for the purpose; and it will be proper, at convenient opportunities, to study in each locality what plants should be selected for the differences of soil where they may be wanted.

That the idea of systematic defensive plantation is not new, may be gathered from the motto at the head of this Paper, taken from Cæsar, and also from our wars in the mountainous parts of India. The proposition therefore is urged mostly on the ground of the vast resources it creates for an Engineer, endowed with a suggestive mind, to adapt available botanical means to the wants and conditions of the problems he has practically to solve.

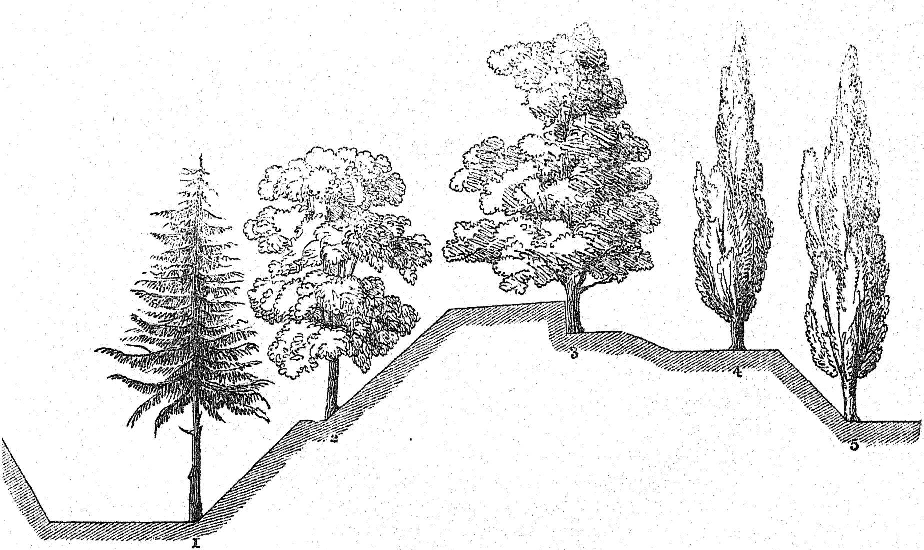
The qualities of trees and plants best adapted for the formation of living, or at least vegetating ramparts, are necessarily,—1st, those which will flourish best in the closest practicable linear juxtaposition; 2nd, those that grow straightest; 3rd, those that have the hardest wood; and, 4th, those that strike the deepest roots. In the tropics alone the Engineer can find evergreen trees with spinous bark; and for covering the front of the approaches, impeding ascent on the rampart, intersecting communications, lining dry ditches, and, above all, rendering escalades and surprises impracticable, the tropics and hot climates again are best provided; though Europe, and even the North, are not deficient in valuable means for effecting the same purpose, provided we remain satisfied with several of the most essential qualities; for all united can seldom, if ever, be found in one species of plant.

In northern and middle Europe the species best adapted are, first, several of the Coniferæ; such as the Swiss pines, the larch, the spruce and juniper pine, the Scots and silver firs, Araucarias and New Zealand pines, &c.; then beech-trees and Lombardy poplar. Where it is desirable to have a rapid growth, the same Lombardy and the small-leaved black poplar; but in the South by far the best is the cypress. Within, and on the borders of the tropics, palms of various genera are decidedly the best, because there are species that thrive in salt water, others in marshes, and many on the uplands and even on high mountains. Though they have very little depth of root, they bear very approximate planting, admit easily of palisades between them, and offer the most enduring resistance to cannon-shot. Research and experience will, most assuredly, discover many other trees and improved modes of applying them, but in a general view, where reasoning from a few known facts, we may draw certain inferences to a given extent. Thus it may be asserted with perfect security in truth, that trees in general are but little shattered by cannon-shot, as from personal examination was proved in the parks and plantations of Dresden, in the great avenues along the Pleisse on the south of Leipsig, and in the gardens of M. Reichenbach, both localities long exposed to most terrific cannonades and unceasing musket fire;* and in 1830

* It was in this garden Prince Poniatowski perished, and nine Polish battalions with four Generals surrendered after a most determined defence, for they left 600 dead on the spot. The close-set trees in the walks alone rendered the protracted defence possible.

the park of Brussels offered the same results. With regard to the trunks of palm-trees, the attack of Mudfort Island, near Philadelphia, in 1777, is a proof that cannon-shot have inadequate effect upon them. Cocoa-trees and other palms will flourish at 4½ feet distance from each other. We have examined a row of cypresses near Marseilles, all from 75 to 80 feet in height, and above 2 feet in diameter, yet not more than 5 feet from each other. In the gardens of M. Reichenbach, already mentioned, several avenues about 16 feet broad were planted with Swiss pines, in some places so closely that it was difficult to pass between them, yet the trees were upwards of 40 feet high, with trunks 18 inches or more in diameter, and literally having the bark on one side riddled with innumerable musket-shots fired into them at the battle of Leipsig, seven years before we examined them. At Neuwied on the Rhine, the 'Allée,' or avenue to the back of the prince's palace, is planted with four rows of Lombardy poplars, many of which are estimated at above 100 feet in height, and the trunks at base nearly 5 feet in diameter: the avenue is broad, but the two rows on each side are scarcely 10 feet from each other, or lengthwise from centre to centre of each tree.

Now, supposing a great front of defence, such as a permanently fortified camp destined to hold up the ultimate vitality of a State, be the object under consideration; and without adverting to the particular system of fortification, as regards the projection the Government may sanction; we confine our view for the moment to the mere profiles of construction intended for the curtains, and allowing the talus to be about forty-five degrees, in order to give greater stability to the trees, we commence near the foot, at a proper elevation above the water, if the ditch be wet, or



at the foot itself, if it be dry: we plant thereon a row of the class of forest trees appropriate to the nature of the circumstances of the works as well as of climate and soil; a second upon the berm; a third forward on the banquette of the parapet, which, being the most important, should be entirely composed of the best-conditioned plants: we then proceed with a fourth at the edge of the terreplein, and a fifth within the polygon at the foot of the inner slope of the rampart. We shall have

in a few years five rows of trees capable of material use in the defence, provided the plants are laterally cleared of branches* as they grow up, and those to the front and rear alone preserved until above 25 feet from the ground. No. 1, the foremost in the *fossé* when a state of siege or attack is apprehended, will be cut down along with that on the berm, No. 2, brought within and employed with No. 5 at the foot of the terreplein, to convert into *palanka*† palisades, in order to fill up the intervals between the living trees of the parapet; to construct *blindages*, bomb-proofs, fraises, and defences for the caponières in the ditch. On the edge of the counterscarp, as also on the crest of the glacis, another row may be planted; and from thence outwards, in quincunx, trees remarkable for striking deep tap-roots, such as Turkey oak, Valonia oak, Ilex, larch, &c. In hot climates, palm-trees, cocoa-trees, date-trees, fan palms, Arecas, &c.; some, like the cocoa, growing in salt water; all which, being cut down at the moment before stated, will suffice to palisade the banquette of the glacis, intersect the external roads for rounds, make gates, and, where necessary, fraise the rampart securely, by connecting the fraises with the stumps of the removed trees.‡

The pine, larch, or fir species, may be planted at 3 feet apart; thinning them out eventually is objectionable.

The enemy cannot see what passes within the lines, nor gain much information, nor attempt an escalade by surprise, much less venture to storm works which he cannot previously dismantle with his cannon. By palanka palisades we understand such as could be made from young trees in the rough, standing above ground irregularly from 14 to 18 feet in height: where unsupported by living trees, they should be completed like a common stockade: climbing over them need not be mentioned as practicable, so long as any resistance is offered even by the worst disciplined troops. In confirmation of this observation, it may be stated, that the Austrians and Russians were in general successful in storming French redoubts protected by ordinary palisades, but that they never ventured to attack the palanka defended redoubts at Dresden; nor did General Maison attempt those of the Saxons covering the gates of Tournay, in the beginning of 1814, they being similarly formed.

On the crest of the glacis and the immediate slope before it, as also to cover caponières, hedges of holly (Ilex aquifolium) will make a very difficult obstacle; and in sandy soils the common furze (Ulex Europeus), when occasionally shorn and trimmed, is likewise convertible to impenetrable hindrances; and where and when required, both may be cut down low without losing the defensive property. As from the palisades the defensive troops behind the glacis can view through the lower part of the hedge the champaign country, and can reach through with the muzzles of their muskets, they can obstinately chicane the outposts, notwithstanding any tirailleur force that may be sent against them, or the grape-shot that may be showered in their direction, because the assailant must be wholly exposed, while the defendants are entirely concealed. Where neither holly nor furze can be procured, yew hedges (Taxus baccata) are likewise very difficult to force, and hornbeam-tree (Carpinus betulus) and blackthorn (Prunus spinosa) may be made to answer in Europe. All these plants require only in the first instance proper selection and preparation of the soil, and subsequently careful trimming and watching.§

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* Care must be taken never to lop the branches within one foot of the trunk, as when cut too close, decay frequently commences at those points.—*Ed.*

† Vide Note, p. 28.

‡ The impediments to Sapping caused by the roots of trees are well known.

§ There are many other available species, and some foreign, that will thrive exceedingly well in Europe, even far to the north, such as the *Carpinus Virginiana*, a quick growing, hard, tall, and very valuable tree; and the Jekoom-tree, in Gujrat, makes excellent defensive hedges.

Such a system would demand in time of peace only a small portion of veterans to guard the works, and among them a certain number trained to trimming and preserving the plantations. When peril threatens, a general requisition of handicraftsmen would in a short time prepare the whole for defence; the resources of the country would take safe shelter behind the lines; and under the command of a few experienced Officers, even a half-trained volunteer population, a landwehr, or a militia, would maintain the position, provided an adequate body of artillery were with it. With the new dangers steam-boat warfare may bring forth, when almost every coast may be threatened with sudden and serious invasion, certain points may be deemed to require such positions of refuge fit for concentration more than formerly.

On a minor scale, and of less importance, are the defences required in the colonial and particularly tropical possessions of the nation. Excepting where the French have built and maintain at a vast expense their citadel forts, the extra European systems of fortification are absolutely insufficient. The ardent sun, violent rains, and frequent earthquakes, together with the economical indifference of the colonial legislatures, cause in particular all English defences to fall to ruin. Instancing Jamaica, the two principal fortified points, Port Royal and Fort Augusta, are (or at least during the wars of the French Revolution were) totally indefensible: both their fronts of defence were of masonry, but cracked by earthquakes, undermined by the sea, filled with sand: the first passable even without a scaling ladder, and the second without ditch, drawbridge, gate, outwork, or glacis. In the one, no guns mounted or fit for service; in the other, most taken off the rampart, and the rest drawn back on account of the insecurity of the wall. All the other fortifications in the island were still in a worse condition: no gun carriages fit for service, and many guns unfit to be loaded.

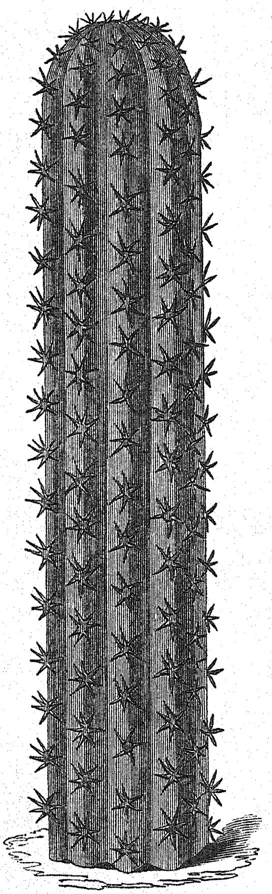
For the defence of all these places positive means exist in the tropics. By the encouragement of the growth of cocoa and mountain cabbage-trees, by the introduction from the Continent of numerous other species of palm, all the sandy and saline lands on the sea-shore may be beneficially and cheaply planted, and in many places they might be arranged in the manner before described so as to form fronts of defence, which, when necessary, would require only the cutting down those that grew beyond the sphere of action, and using them as palisades, &c. Dear-bought experience has taught us the formidable nature of bamboo stockades and bound hedges; it suggests similarly that the bamboo should be encouraged in the West India islands, where we have seen clumps in luxuriant growth reaching to 60 feet in height, both on the plains and in the mountains. Both these vegetable families of plants thrive in poor as well as deep soils, and for outworks the Euphorbiæ, Agaves, Cactus opuntium or Echino cactus, Cactus Ficus Indicus, the aloes, and many other thorny productions, require only the care of protection to be made formidable for defensive purposes.

In Jamaica, during the martial law of 1805, it was exemplified what could be done with the botanical resources for the defence of the forts so defectively constructed as above shewn. Representations from the island Engineer to the island Legislature, recommending a very considerable increase of cocoa-trees, by planting the nuts within the fences of the '*pens*,' country residences in the plain of Liguana, and bamboo on the rocky hills, had indeed been received with approbation, but were not put in execution.

But Fort Nugent, at the head of Kingston Harbour, requiring to be placed in a state of defence, advantage was taken of the momentary alarm to cover the front of the whole position in three successive belts, each 9 feet in width, with close-set plants of the Cactus (opuntium) undecimalis, a succulent plant growing abundantly on the spot; and although at first military men thought the element employed of little or no defensive value, as the work increased their opinions changed, and some

years after, when the late General Sir Charles Shipley visited the ground on his tour of inspection, he expressed his unqualified approbation of the use of the plant and the method pursued, although from the short duration of military law, the whole system had not been completed. The Opuntium undecimalis was introduced from the Spanish Main, and in Peru grows to 25 feet, and branches out. In Jamaica it generally forms but one upright unbranched stake, about 7 inches in diameter, having eleven ridges and as many right-angled furrows. Upon the ridges are grown burrs or tufts of silicious spines exceedingly strong and sharp, three or four of each burr being from one to one and a half inch in length. They stand about 3 inches apart, but each alternate ridge has them on the intermediate distance, so that a human finger can scarcely touch the smooth green rind without being painfully wounded. Set in juxtaposition, and temporarily kept in line by stakes and poles, they form a close hedge, impenetrable even to a rat. Musket and cannon-balls make mere holes through them. Being succulent, they cannot be burnt; and when cut down they are still impassable, since the thorny spines strike through a boot sole, and the wound is almost invariably fatal, by producing tetanus or lock-jaw. Such was the case with the only three negro pioneers who, notwithstanding the care taken by them to move and set up the plants with long wooden pitchforks, were pricked in the feet and died. Hedges thus set up 9 feet asunder, the intermediate space was planted with lower choppings, and nearly all grew in the dry sand without further trouble than taking the precaution to have each section or cutting seared by exposure to the air for a few days: this should be done in the shade, and last about twenty to twenty-five days before setting. The hedge pieces were 3 feet long, giving little more than two above ground; the inner pieces only a few inches. Had there been an abundance of bamboo plants, the whole parapets and bound hedges would have been fraised in the Indian manner in the condition described; but there was no likelihood that a hostile force would have dared to attack the position. Prickly pears and even aloes may serve as substitutes, but the Opuntium may be deemed insurmountable, and certainly becomes more and more so with age, provided care be taken to preserve the belts in due order.

Cactus undecimalis, now probably Echino cactus undecimalis.



Such is the theory and the limited practice hitherto given of a system of defence by means of the living vegetable productions of the climate where it may be put in execution.

DEFENCE OF FORTRESSES.*

THE RECONNOISSANCE OF THE GROUND OUTSIDE THE PLACE.

1. *The Circle of Action.*—The first duty of a Governor, or Officer Commanding, from the moment of his entering upon his functions, is to study every thing which concerns the defence of the place which is confided to his care. He will therefore make himself thoroughly acquainted with its topographical situation; its connection with the neighbouring fortresses; with the frontier in general; with the offensive and defensive operations of the armies in the field, and with the part it might have to play in such operations.[a]

2. *Circle of Investment.*—After having gained this preliminary knowledge, the Commandant will apply himself to study, more in detail, the ground which may be included within the circle of investment *as far as the most favorable situations for the enemy's parks, and their lines of circumvallation.* He will study all the undulations, in order to profit from the advantage they may offer of confining the enemy in choosing his ground of encampment. Whilst he is employed in gaining a familiar knowledge of the ground, he must calculate beforehand the way in which he could most injure the enemy, without exposing his own troops to be cut off in their retreat.

3. *Circle of Attack.*—Within the circle of attack (*which extends from the glacis as far as a circle which will include, in case of siege, the enemy's dépôts, and the tail of their trenches, a distance of nearly* 1100 *yards from the crest of the parapets of the most advanced covered-way*), the Governor, or Commandant, will keep a strict watch to insure that, in conformity with his Instructions, no buildings or establishment whatsoever shall be made which might serve as cover to the enemy.

4. If the fortress should possess the means of covering any of its fronts by inundations, he will make himself acquainted with the time necessary to form them: he will take care that the bâtardeaux and sluices are in a good state, and that the latter can be worked with facility.

THE RECONNOISSANCE OF THE FORTIFICATION.

5. *Of the Main Enclosure.*—The Governor, or Officer Commanding, will reconnoitre, in concert with the Commanding Engineer, the enclosure of the fortress, the nature of its fortifications and works which compose it, both as they relate to the defence in general and in detail: he will carefully examine whether the parapets are high enough to cover the men and guns; also if the scarp wall be such as to be secure against escalades, or an attack by coup-de-main; in fine, whether each of the works be capable of being retrenched, or of being otherwise improved.

6. *The Outworks.*—After having examined the enclosure, the Governor will inspect all the works comprised under the denomination of *outworks*, and which are situated in the ditches of the place, such as ravelins, counterguards, tenailles, &c.: he will study in what degree they aid the defence of the Body of the Place, and the

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* Taken from Instructions issued from the French Imperial Minister of War (Carnot), and translated by Lieut.-Colonel Reid, R. E., with notes by Major-General Sir John Burgoyne.

[a] When the French were in possession of most of the fortresses in Europe, and were thrown on the defensive, it became a great object to stimulate the Governors and garrisons to the most vigorous defences. Hence, he (Carnot) takes a most sanguine view of the resources of the besieged, and the principles inculcated imply a power and means that will rarely exist, and a considerable degree of energy all on one side of the question.

Still the lessons are very valuable as instructions how to apply whatever resources may be available. —J. F. B.

reciprocal defence they give and receive, as well as the peculiar use which may be made of each in the general defence: he will satisfy himself that their interior is well under the fire of the Body of the Place, and that the communications between them and it are secure.* His reconnoissance must include every gate, sally-port, and issue, by which he might be enabled to fall with rapidity on the enemy, whether for the purpose of preventing a passage of the ditch, or to dislodge him from an outwork which he may have gained.[b]

7. *The Covered-way.*—The covered-way will be the object of particular attention: the Governor will examine whether all the branches be directed in such a manner as distinctly to see the surrounding ground; whether the traverses be in a good state; if the banquettes have the proper dimensions; if there be a sufficient number of barriers for sorties, and if they be properly disposed, and sufficiently palisaded.

8. *Advanced Works.*—The advanced works of a place ought to increase its capability for defence. The Governor will consider for what purpose they were constructed; whether they will perform the part for which they were intended; whether their communications be secure and easy; and above all things, whether their interior be properly seen from the Body of the Place, or intermediate works; because in this case they present much greater difficulties to the besiegers in lodging themselves within them, and they facilitate those offensive operations of the besieged (*retours offensifs*) in which the most important part of the defence of fortresses may consist.

9. *Detached Works, Forts, and other Dependencies of the Place.*—The object of these works is in general to see into places where the undulations of the ground would otherwise give cover to the enemy; to occupy a point which commands the fortress; to protect a dyke or sluice which supports an inundation favorable to the defence; or to take in reverse the approaches of the besiegers.

10. *The Reconnoissance of the Interior of the Place.*—He will be equally careful that the streets which serve as a direct communication between the Great Square, or place of general parade (place d'armes), as well as between the military buildings and establishments, and the streets adjoining to the ramparts, shall neither be shut up nor narrowed, without the plans for the purpose having been previously concerted in conjunction with the Military Engineers.

11. He will examine with care the site of all military buildings and establishments; the esplanades, and all other grounds connected with the fortification, so as to be able to judge what relation they bear to the Body of the Place in case of attack, or with the rest of the interior in case of alarm.

He ought also to know the situation and capacity of such public and private buildings as might be converted into use, as well as what casemates and strongly arched cellars or cover there may be, to protect the provisions and to quarter the troops and the sick.

12. He will examine carefully all the water courses[c] in the interior of the place, the bridges and sluices, the rivers, canals, aqueducts, drains, &c., in order that all the issues by which an enemy might possibly get into the place be perfectly known

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* Or what temporary means can be applied under different circumstances of a siege to make them so.—*Translator.*

[b] And study how they are to be best secured in those times, of usage or otherwise, against becoming an inlet to the besieger.—J. F. B.

[c] The French fort at the Retiro (Madrid) was supplied with water by an aqueduct, which being cut off, the only resource of the garrison of 2000 men was a single well, with a rope and bucket; and at the castle of St. Sebastian, the only supply of water, a spring, was exposed to the fire of one of our batteries on the island of Sta. Clara, to the great inconvenience of the garrison.—J. F. B.

to him: he will see that the gratings, or other contrivances for closing them, be kept in good order, and he will, personally, take the greatest care that none of the precautions against surprise be ever neglected.

OF THE ARTILLERY AND AMMUNITION.

13. *Of the Artillery and Ammunition.*—The Commandant will draw up, in concert with the Commanding Officers of Artillery and Engineers, the plan for arming the fortress, with the number of pieces of ordnance which may be necessary, and their stores. He is to verify the reports personally, to see that they actually agree with the state of the stores, and whether there be all the necessary compositions and other auxiliaries (*feux d'artifice*) for defending the breaches, the passages of the ditches, and for throwing light on and discovering the approaches of the besiegers.

See Appendix I. & II.

He will concert with these Officers the various positions in which his artillery may be placed in relation to the supposed attacks of an enemy; and he will also determine on the means to be employed to cover it from their fire.

See 'Blindage.'

OF THE ENGINEERS, AND THE MATERIALS RELATING TO THE DEFENCE.

See Appendix II. & III.

14. The Governor will examine, in concert with the Commanding Engineer, the state of the storehouses and materials for the fortifications: he will acquaint himself whether there be in the fortress palisades in sufficient quantity to replace such as may be destroyed; whether there be a sufficient quantity of gabions, fascines, hurdles, beams, planks, round timber, cordage, iron, intrenching tools, miners' and carpenters' tools, nails, chevaux-de-frize—in short, every thing that is requisite for defence.

OF THE PROVISIONS, AND THE OTHER MATTERS BELONGING TO THE COMMISSARIAT.

See Appendix III.

15. The Governor will examine into every thing which may concern the subsistence and the health of the garrison and the inhabitants: he will cause reports to be made to him of the grain, and liquor of every description, which he will personally verify: the description and state of the ovens will be inspected, to be assured that they will suffice for the garrison.[d]

16. The quantity and quality of provisions of every description ought to be perfectly known to him, in order that, calculating the force of the garrison and the wants of the place, he may take the necessary measures for keeping them complete, or for sparing them, in order to prolong the defence as much as possible, in case circumstances should not have allowed him to lay in all that may be proper.

17. He will visit the magazines of provisions, that he may know whether every thing relating to them be well regulated, and each species of provisions be stowed in the most appropriate place. Looking forward to the necessity of placing them in security in case of siege, should the town not contain a sufficient number of casemates, he will take an account of all the buildings, and particularly of cellars which may serve this purpose, in order, if required, to render them proof against the projectiles of the enemy. This precaution should extend to all the stores and provisions for the siege, to whatever Service they may belong; and a fair division should be made of the bomb-proofs according to the real wants of each branch of the Service, and not to demands often exaggerated.

18. The hospital merits very serious attention; the Governor should examine whether it admits of being 'blinded' (*blindé*),* and if it would be sufficient for the

[d] He will see that the supply of fresh water is such as cannot be cut off or destroyed by the enemy. —J. F. B.

* Converted into a temporary bomb-proof by strong timbers.—*Translator*.

necessities of the garrison during a siege.[e] In case it would not, the Governor will fix on one or more large and commodious buildings for the purpose, in order to cause the necessary work to be commenced for the security of the sick, from the moment the place may be threatened.

RETURNS OF STORES AND MATERIALS; OF PROVISIONS; AND OF ARRANGEMENTS TO PREVENT FIRE.

See Appendix I. II. III. & IV.

19. The Governor will cause returns to be made of every thing useful in case of siege, whether it be in the town or surrounding country, that he may be enabled, at the moment of need, to collect whatever may benefit the defence, and to destroy whatever may be hurtful to it by falling into the hands of the enemy.

20. He will cause the inhabitants who ought to remain in the fortress to provision themselves in due time, for a period, at least, as long as that for which the garrison is provisioned: he must make them understand the necessity of not waiting till the last moment for supplying themselves with the things they require for their consumption, because they ought to know that their interest, in this respect, is the same with that of the defenders; and that those who are herein guilty of neglect will run the risk of want during the siege, or of being turned out as useless mouths.

OF THOSE PREPARATIONS FOR DEFENCE WHICH BELONG TO THE STATE OF WAR, AND ESPECIALLY ON THE PROSPECT OF A SIEGE.

21. The Governor will accelerate the works of defence by every means in his power.

22. He ought now to commence the inundations, if they are slow in forming themselves, and to fill the reservoirs which are to sweep those ditches which are intended at first to be defended as dry ditches.

See Blanshard's Pontoons, Article 'Bridge.'

23. He should construct bridges of rafts, to communicate across ditches and rivers: such bridges cannot be destroyed by the enemy's artillery, and may be made to bear the heaviest weights.

24. In sea-ports and in fortresses situated on great rivers, or fortresses in front of which wide and deep inundations may be formed, he will collect armed boats. The mode of arming them must be concerted with the Commanding Officers of the Artillery and Engineers, and, when there may be one, with the senior Officer of the Navy.

See Appendix III.

25. The Governor will apply himself, with the greatest diligence, to all that regards the provisions and stores of every species, and he will use all means to make them complete and to keep them so: this is the most delicate part of his duty, and that in which negligence might cause the worst consequences.

If all the grain be not ground, he will cause it to be done, or else satisfy himself that there is the means for grinding it during the siege, by constructing in time either hand-mills, or mills to work by means of horses.[f]

26. Great fortresses alone have the property of having some part of the interior little exposed to the enemy's fire: such an advantage is precious. It is in those parts that it is of consequence to deposit such provisions and stores as are most valuable, avoiding, however, to unite them in mass, that they may not form a focus for conflagration.[g]

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[e] And if situated in a position little likely to be exposed to the fire of the besiegers.—J. F. B.

[f] British troops are accustomed to the use of sea biscuit, which forms an admirable article for lengthened storage. The French seem to have an objection to it.—J. F. B.

[g] It is peculiarly necessary to have the magazines for ammunition well subdivided, so that an accident to any one should not be fatal to the place: the principal magazine should never be resorted to for ordinary daily consumption, but the smaller magazines kept supplied from it at particular and rare times, when that service is least likely to lead to danger.—J. F. B.

Magazines of wood and forage ought to be in the open air, in small isolated stacks. The daily issues can be very well made in sheds.

27. When the town is small, and where there is no quarter that will not be very much exposed to the effect of the enemy's projectiles, the bomb-proof covers must be multiplied as much as possible by means of blinds (*blindages*).[h] Such shelter is formed in a short time, and only requires timber and earth. Buildings having thick walls may be advantageously used for the purpose; they should be blinded on each story if possible, the useless doors and windows should be blocked up, and in this way healthy bomb-proof cover may be obtained for the defenders, and especially for the sick.

See Article 'Blindage.'

See Appendix II.

28. If there should be neither building fit for blinding, nor yet bomb-proofs in a fortress, their place may be supplied by forming blinds, of trees leaning against each other in a sloping position, or being placed inclined against revetments or solid walls in those parts which are the least exposed.

See Article 'Blindage.'

29. The same measures should be adopted for the powder magazines if they are not already bomb-proof. Such as exist ought to be solidly blinded; and if they should not suffice, then dry cellars must be occupied and blinded.

30. The wells and cisterns which may be necessary for a supply of water must be also blinded.

31. After these details it will be seen how necessary timber is in a fortress. Therefore the Governor must neglect no means of augmenting his store of that useful article.[i] It is also required for retrenchments, for wooden tambours, for fraises and palisades, for repairing damaged gun carriages, for constructing rafts, &c., and for the consumption of the garrison.*

32. If the front of attack be determined by the nature of the ground, the Governor will cause the bastions to be retrenched beforehand. He will form cuts in the outworks if they will admit of it, and he will cause a supply of gabions, fascines, sandbags, and palisades to be carried to them, that he may be able to retrench and defend the breaches, and he will construct such traverses as may be necessary.

33. Should the front of attack not be absolutely determined by the circumstances of the place, the knowledge of the fortress which he will have acquired ought to

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h It must be observed that such arches as are constructed as bomb-proofs, and are so much so as to resist *any* one shell that can fall upon it, are not to be considered as affording absolute security. For such arch may not resist a *number* of heavy shells falling upon it: this may happen accidentally when the bombardment is heavy, or when the building is seen from without; or its position well known, it may be battered as it were by vertical fire, as well as an ordinary wall is by horizontal fire; and this has been done frequently against principal magazines, and with success.

A kind of barrel has been adopted in the Navy that has a door or available opening, and is perfectly secure against water or damp: it is suggested that barrels large and small, on that principle, might be constructed without any great increase of expense, that would be very useful for damp places or magazines for the land service.

See Article 'Coast Defences.'

It will be remarked that many of these wants are created by imperfections in the fortress; most of them should be permanently provided for in the original construction, and only those required at the period of the siege as are dependent on the operations of the besiegers, and consequently could not previously be regulated without an excess of expense, by providing for *every part* means that may be only wanted on one.—J. F. B.

See 'Defensive Elements.'

i The advantage arising from planting the ramparts and open spaces within fortresses has been always admitted, and yet it is not always practised.—J. F. B.

* An order was issued in 1795 to plant the glacis of every French fortress with trees, for reasons which are given at length in the 155th paragraph of St. Paul's 'Traité Complet.'

At the siege of St. Sebastian, when attacked by the English in 1813, the trunk of a large poplar-tree completely stopped the progress of the Sappers, and defied all their efforts to move it, until one of them gallantly jumped from the trench, and stood exposed until he moved it from the head of the Sap, and returned without being wounded.—*Translator*.

enable him to judge which side the enemy will choose in preference. There he ought to prepare the means of defence, that he may be able to execute the works which may be required, as soon as the operations of the enemy shall have shewn his real designs.

See Article 'Boom.'

34. In fortresses situated on rivers, stockades or barricades should be made where they enter, and where they issue, in order that nothing may possibly insinuate itself into the place. They must be moveable where there is a power to send out armed boats to outflank the enemy's attack when the banks will admit of it, or for other purposes.

See Appendix I.

35. The Governor will cause the first disposition of the artillery against the beginning of the enemy's approaches (and which will have been previously concerted) to be carried into execution, as well as the armament of batteries of which the position is fixed, such as those of cavaliers, of flanks, of works covered by inundations, &c.; but all others ought to be established successively, according to the progress of the attack.

The point of importance therefore is not that batteries should be made beforehand, which may remain for a long time, or for ever useless, but that the nature and effects of the different species of ordnance of all calibres should be well understood, in order to determine in what way they shall be employed during the various circumstances which arise in a siege.

See Plate of 'Defence of Fortresses.'

Above all, the very oblique fire (*feu d'écharpe*) must not be neglected, by establishing batteries on those works which are collateral to the front of attack.

OF THE STATE OF SIEGE, DIVIDED INTO FIVE HEADS; AND TREATING OF IRREGULAR ATTACKS, WHICH MAY PLACE A FORTRESS SUDDENLY IN A STATE OF SIEGE.—FIRST HEAD.

36. *Of Surprises by the Enemy, or by revolted Inhabitants.*—The Governor, responsible for the place confided to his care, ought to neglect nothing to prevent surprises, and should take the most minute precautions against their occurrence. The following measures should be adopted: to repair every part of the rampart by which an enemy might insinuate himself into the place; putting double gratings to the drains or aqueducts, and placing sentries to watch them; and always to have at hand, at the point of danger, detachments which may be brought up rapidly. He should likewise shut up all the embrasures or openings that may be too low.

37. If there should be no drawbridges in front of the gates, palisades or advanced barriers should be constructed, and warders posted in them for the purpose of stopping strangers and examining waggons.

All openings caused by rivers should be shut in a similar manner; and all boats carefully searched.

Before the gates are opened, some soldiers should patrol and search all places where an enemy could conceal himself.

Persons waiting at the gates for admittance should be examined; loaded waggons should be forced to keep off to a distance, and should be probed; the second gate should not be opened until the first is closed and the drawbridge raised; the guard should be under arms inside the gate; waggons should be admitted only one by one, and never be suffered to halt between the gates; care should be taken that the portcullis be in a proper working state (if one exist), and that the mode of using it be explained by the old guard to the new at the time of relief.

38. In time of frost, the ice in the ditch must be broken every day. In such a case, when a channel has been made in the middle of the ice, a boat* should be con-

* Carried into effect by Rapp at the Siege of Dantzig, 1813.—*Ed.*

tinually dragged up and down, which, by its motion, will prevent its connecting itself again.

39. There should be no remission of the precautions in very wet or inclement weather, and in fogs they should be doubled; the approaches to the counterscarps watched, by posting a sufficient number of sentinels and small parties in the covered-way, so as to prevent an enemy's being able to pass between two of them, and to enter it without being seen.

40. To protect himself against revolts in the interior, he must establish a severe police, and study well the character of the inhabitants; and if he has reason to fear them, they must be disarmed: and he must take measures of precaution in time, such as to fortify the guard-houses and selected strong buildings against the town, to have artillery ready to occupy all the streets leading to the spots most favorable for large assemblies, and to secure the avenues of the citadel or keep, in which the service must be performed in the strictest manner to prevent surprises.

SECOND HEAD.

41. *Of Escalades.*—Every thing which has been stated in the preceding paragraph relating to surprise applies to this; because, if proper precautions have been taken, it will be difficult, if not impossible, for the enemy to get into the ditches of the place and to plant ladders without being discovered, or without the garrison having timely notice of the design, and being in a state to defeat it.[k]

THIRD HEAD.

42. *Of Attacks by sudden Assault.*—Attacks by sudden assault, or accelerated sieges (*siege brusqués*), are, properly speaking, a species of surprise against which the vigilance and precaution recommended in the preceding paragraphs are the most effectual preservatives. Nevertheless it may occur that the enemy, pretending to besiege the place regularly, may happen to accelerate the approaches against one of the fronts of the fortress: it is necessary in such a case to fall upon him vigorously, and to leave nothing undone to drive him from the works of which he may have taken possession.

43. One may suspect his intention if he does not make his attacks on that side of the place where he ought naturally to do so, in order to take it in the easiest way.

In such case the watchfulness on that side ought to be doubled.

44. In general it should be considered necessary to watch every front of the fortress.[l] Even when it is evident from the works of the enemy, which is his point of attack, the other sides must not be neglected; but it becomes more particularly so when there is a point which is admitted to be accessible, that it is of importance to take every precaution against sudden assault, and to do all that is possible beforehand to render it secure.

FOURTH HEAD.

45. *Of Bombardments.*—Simple or irregular bombardment may be either effected

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k Against escalades and accelerated assaults in general, the most essential means of defence is in a flanking fire; it is far better to make that efficient than to disseminate the forces all along the lines.—J. F. B.

l The parts of a fortress not connected with that which is absolutely attacked should be placed in divisions, each under a distinct charge, the Officer appointed to which will study the locality, and take every precaution, with as much consideration and energy as if certain that some effort would be made against him: if such arrangement had been made, it is very possible that neither of the assaults that actually carried Badajos in 1812 could have succeeded.—J. F. B.

See Article 'Bombardment.'

See 'Defence of Coasts.'

by a corps of an army, which is too weak to invest a place, planting mortars hastily opposite to one of its fronts; or by bomb-ships, if the place be a sea-port. The Governor ought in such case to try and destroy the land batteries by sorties, or to burn the squadron. In either case he should multiply the number of guns on the faces which see the line of the enemy's fire.

46. Against such attempt the Governor should cause the ammunition and provisions to be placed in casemates or under bomb-proof blinds; or at least to place them in the parts of the town the least exposed to the enemy's fire.

47. He ought to establish measures for maintaining tranquillity amongst the inhabitants, and to take every precaution against fire. A well arranged organization renders the effect of incendiary projectiles less likely to be very serious: sentinels taken from the companies of firemen (*pompiers et gardes-feu*) watch the fall of shells or the direction of red-hot shot; those on guard, furnished with buckets, run to the spots where fire shews itself, and put it out at its commencement. They follow the red-hot shot, throw water into the holes which they have made, seize hold of them with pincers, and carry them away in metal spoons or vessels to the nearest reservoir of water. By following this system there is less reason to fear extensive fires breaking out; and as the inhabitants themselves are interested in establishing the strictest watch, the enemy will probably not succeed in destroying the town, and he will have consumed his ammunition in vain. All examples prove that this mode of attacking places, at the same time that it does not destroy the fortifications, causes little loss to the besieged.

FIFTH HEAD.

See Article 'Blockade, Military.'

48. *Of Blockades.*—It sometimes happens that the enemy being unprovided with the means required for undertaking all the works of a siege, and supposing the place to be badly provisioned, confines himself to closely blockading it, by seizing all the avenues, in order to prevent the arrival of any succour, and to force it to surrender by famine.

49. The dispositions to be made in this case are, to send away all useless mouths; to cause all the means of subsistence which the environs of the place may furnish to be brought into the town; to use the strictest economy in the distribution of provisions, and to watch the consumption of those of the inhabitants, that they may make them serve whilst the fortress holds out to the last extremity.

50. If, to a blockade, the enemy should join a bombardment, the precautions recommended in the preceding paragraph against fire, and for the security of the provisions and ammunition, ought to be made use of. As to the defence in these two cases, it should be external.

OF SIEGES, OR REGULAR ATTACKS.—FIRST HEAD.

51. *From the Period of Investment to the Opening of the Trenches.—Lines of Circumvallation, Countervallation, &c.*—The presence of an enemy's army within three days' march of a fortress, places it in a state of siege. The Governor being previously informed of the projects of the enemy, ought to have every thing prepared for resisting a regular attack as long as possible.

52. As soon as the enemy approaches to invest the place, the Governor finishes his first preparations with all possible activity; he occupies such advanced posts as may have their communications with the fortress secure; he sends patrols in every direction to get information of the enemy's movements, and to find out as well as they can, his force, his projects, and his means of executing them.

53. The investment being effected, the enemy's camp will be drawn on the plan of

the place, according to which the Governor, in concert with the Commanding Officers of Artillery and Engineers, will regulate his arrangements for the defence in proportion to the enemy's progress.

Vide 'Attack,' p. 89.

54. If the garrison be strong, some sorties may be hazarded; but it is seldom that sorties at such a distance succeed, unless it be in consequence of the fault of the besiegers in neglecting the ordinary precautions. They are besides very fatiguing for the garrison, which it is more advantageous to employ in executing the pressing works always required in a defence.

55. At night he will send out small parties in opposite directions, who will creep along, taking advantage of banks or uneven ground, and proceed in silence as far in advance as possible; then, lying flat on the ground, they will listen with attention to the smallest noise; they will afterwards retire on the fortress in extended but connected order, to try to surprise Officers who may be out to reconnoitre the place. These parties must agree on a signal that they may know each other.

Vide 'Defensive Precautions.'

56. In the first moments, the Governor may employ his good marksmen advantageously.[m] Wall-pieces should be placed on the most elevated situations, and he should mix some of the marksmen with the parties sent outside the place, with orders to fire on those who may be attempting to reconnoitre the fortress.

57. It is at nightfall that these marksmen, &c., ought to watch with the greatest attention; that being the period for reconnoitring, tracing, and pushing forward the attacks.

SECOND HEAD.

58. *From the Opening the Trenches to the Crowning of the Covered-way.*—As soon as it is known in what direction the enemy is opening the trenches, the Governor should cause embrasures to be opened, and platforms to be laid for the guns; double rows of palisades to be planted in the covered-way; useful temporary works of fortification to be made, such as flèches at the foot of the salient angles of the glacis. These flèches, made capable of resisting a coup-de-main, retard considerably (as is well known) the commencement of the third period of the siege, which is the most important: he should have mines under the glacis, to be prepared with diligence; bridges of communication, to be promptly established, for which timber ought to have been prepared beforehand, and placed in store; and the retrenchments of the outworks, and of the bastions, should be proceeded with the greatest activity. If these retrenchments are not ready made, and have not revetted scarps, they should be as solid as earth and fascines can make them, and according to plans which should be well digested long before.

See Appendix V.

The same applies to redoubts in the salient and re-entering places of arms.

59. If there be no caponières communicating between the place and its outworks, the Governor should cause them to be made.

60. When the enemy shall have forced the outposts to fall back, the Governor ought to keep his garrison as much as possible behind the advanced works, and to preserve for himself as long as he can, the attitude and energy of the offensive. The garrison, posted thus, is in the best possible condition for sorties.

They should be at one time great sorties, at another time petty ones; sometimes false, and often real.

The Governor's object ought to be to torment and harass the enemy, and to keep

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[m] Field-pieces and wall-pieces should be placed in the most commanding positions, and fired, without sparing, against the reconnoitrers, whether in bodies or single.—J. F. B.

him continually on the alarm, which will cause him to lose as many men by fatigue as by fighting.

Sorties have always the effect of interrupting the enemy's works, and of dispersing the workmen. In the confusion and obscurity of night it is difficult to assemble them again and to set them to work.

In serious sorties there should always be working parties to destroy and fill in the trenches, and some draft-horses to carry off cannon which may be taken.

See Appendix II.

61. As the works of the enemy advance, the Governor ought to endeavour to outflank the attacks, either by armed boats (in places situate on rivers or on the sea) or by pushing out lines of counter-approach.

These lines are a species of trenches which run out from the covered-way on the right and left of the attacks, to enfilade the works of the enemy. They ought to be applied with circumspection: destined to outflank the enemy's trenches, they should not be enfiladed themselves. They ought therefore to be adapted to the nature of the ground, in such a manner that their prolongation shall fall on hollows, rivers, ravines, or in marshes, beyond which cannon cannot act against them with effect; and that they shall terminate, if possible, upon some inaccessible piece of ground, that the enemy may not have it in his power to cut them across by a boyau from his trenches, or to envelope them in an attack.

62. Good marksmen * may also be sent out a little before daybreak, who should place themselves flat upon the ground on the prolongation of the advanced trenches.

If there be any light artillery, some pieces of small calibre may also sometimes join these marksmen.

See Appendix V., and Articles 'Fougass' and 'Military Mine.'

63. When in spite of the efforts of the besieged to retard the advance of the attack, the enemy shall have arrived on the glacis, the Governor will employ all the resources of subterraneous warfare, which may either form part of the fortifications or which he may himself have contrived.

A well-directed fire crushes the heads of Saps; the marksmen posted in the covered-way retard the progress of the works; small sorties upset them.

64. When the enemy's works are destroyed by mines, the besieged should take advantage of the disorder of the enemy, and upset as much as they can of his works.

65. If the besiegers decide to assault the covered-way, the salient parts, which are under the protection of the fortress and its outworks, should be defended as long as possible.

66. If the enemy be most decidedly superior, the salients should be abandoned to him, and the re-entering places of arms firmly maintained. The enemy should be left for a while exposed to shells, grenades, and stones; after which, the besieged should debouch from the re-entering places of arms, not only of the fronts attacked, but from the adjacent fronts, to drive him back and to destroy his lodgements.

See 'Sapping.'

67. If he decide on crowning the glacis step by step, the progress of his Saps becomes slow and deadly: in order to drive the defenders from the salients, he must construct trench cavaliers, the formation of which is long and perilous; or powerful batteries, which are difficult to erect, under the close fire of the place. After which, in carrying his lodgement along the crest of the glacis, he must successively drive the besieged from each traverse: master of the branches, he has to attack the re-entering places of arms and their redoubts; and it is only by sacrificing a number of men, and by surrounding himself with traverses, that he can protect himself from the reverse fire of the outworks, and make himself master of the covered-way.

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* Vide 'Defensive Precautions.'

THIRD HEAD.

68. *From the Crowning the Covered-way until the Assault.*—After the capture of the covered-way, the besiegers endeavour to establish their breaching batteries; their construction is retarded by deadly projectiles; they are counter-battered by very oblique batteries (*en écharpe*) which force them to the construction of reverse traverses.

69. The breach being made in the ravelin, the enemy commences his passage of the ditch. He must make epaulements; or if the ditch be full of water, he must make a bridge of fascines to arrive at the work. The besieged oppose this dangerous operation by all the means which are left them; they overthrow the bridge and the epaulements by their batteries, disperse the workmen by their stone mortars, their howitzers, and their hand-grenades; and (if they have any) they bring forward their armed boats, until this period kept behind the tenailles, to open a destructive fire on the passage of the ditch.

70. If the nature and construction of the sluices will admit of it, they suddenly open them, overthrow the bridge, and sweep it away.

71. If the ditches be dry, they assemble sorties behind their caponières and tenailles, march rapidly on the works of the passage of the ditch, and with hooks drag down whatever it may be composed of, hastily setting fire to the fascines or other combustible materials of which it may be formed.

e Article 'ougass.'

72. The Governor endeavours to clear the breach as it is made, in order to render it less practicable; he prepares fougasses under it; he buries shells and boxes of combustibles in it; he then forms abattis, plants palisades, chevaux-de-frize, and prepares vigorously to dispute it with the besieger when he shall assault it. Here the whole energy of the besieged should be displayed. They have no longer to withstand the whole of the enemy's artillery, which must cease firing on the breach, when the besiegers are ascending it, whilst their own, fires incessantly upon the narrow defile by which the assailants arrive at it.

73. It is for the Governor firmly to convince his garrison that the most dangerous operation for the besiegers, and that most likely to cause his defeat, is the assault.

74. Such are the obstacles the enemy ought to meet with, in possessing himself of the breach of the ravelin, which he may besides find defended by a cut yet to be disputed. If this ravelin has a redoubt, a new operation has to be commenced, a new breach made, a new passage of the ditch, and another assault to be given; for a Governor cannot be supposed to give up a work without having defended it to the last extremity.

75. Master of the outworks, at the expense of so much time and blood, the enemy has immediately to re-commence a new and more dangerous attack against the Body of the Place, to make a passage of the ditch longer than the former, more bloody, and easier to be destroyed.

76. The Governor should have some resolute men to clear the earth from the breaches: this operation retards the assault, which can only be given when they are practicable.

77. With a garrison which is well disposed, a Governor may undertake works of the most extensive nature during a siege, and even under the enemy's fire.

78. After having long disputed the passage of the ditch, he must stand the assault of the Body of the Place.

e Appendix II.

79. The Governor's duty is to make use of every effort to defend the place to the last extremity; and it is not until he shall have expended every resource, and when it shall be out of his power to repair his last retrenchments, on the point of falling, that he may consent to surrender.

APPENDIX I.

PROPORTION OF ARTILLERY NECESSARY.

The quantity of ordnance, and relative proportion of artillerymen, carriages, ammunition, and stores, necessary for the defence of a place, are detailed below; but attention will of course be needed to suit particular circumstances, which may be done by the Artillery Officer employed in the armament of fortresses, who may modify them according to local circumstances, having in view that they do not apply to the sea fronts of maritime places, the armament of which will be found in the article 'Defence of Coasts.'

It is necessary to observe that some rule* must be established to provide for the probable wants of the Artillery; in like cases, that Service forming the most important means of resistance in the defence of places; and hitherto there is no sufficient authority to quote; therefore the principles given in the article 'Artillery,' Section V., of this work, will be followed, of having 10 per bastion for the immediate security of the fortress.

And providing for those of the first class 110 pieces,
second „ 70 „
third „ 30 „

in the proportion of heavy guns $\frac{5}{10}$, howitzers $\frac{1}{10}$, mortars $\frac{3}{10}$, and field-pieces $\frac{1}{10}$, consisting of the following calibre:

	a	*a*	*b*
Guns .	32-pr.	24-pr.	18-pr. and field-pieces,
	a	*b*	
Howitzers	10	$6\frac{1}{5}$ inch,	
	a	*b*	*b*
Mortars .	13	8	$6\frac{1}{5}$

a being for immediate security, and those marked *b* as necessary to sustain a siege; the number of artillerymen being—

7	rank and file for each	heavy gun.
6	„	howitzer.
5	„	mortar.
8	„	field-piece.

To which, during the siege, an equal number of men of the Line should be added to assist in the Artillery duties.

The number of carriages—

One traversing platform for each salient angle of bastion.

One carriage + $\frac{1}{5}$ for each gun and howitzer, allowing garrison carriages for those mounted in the flanks and those mounted for the security of the place; and travelling carriages for the guns in store to be mounted after the investment.

One mortar bed + $\frac{1}{10}$ for each mortar.

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* The determination of a Unit for defence has been a subject of some discussion, in which different propositions, such as—A The strength of the garrison,
B The number of pieces of ordnance,
C The number of fronts,
have been made, but they are virtually the same thing, being, cæteris paribus, proportional to each other. Hence, for the sake of clearness, general convenience, and consistency,

In Appendix I., for the Artillery Service, B is assumed.
In No. II. (Engineer) the same 'convenience' requires a reference to A B C forms of unit.
In Nos. III. IV. (Provisionment) unit A.

The *quantity of ammunition* required should be regulated by the description of fortress; those of the

1st class having	700 shot and	500 shells.	Rounds per piece.
2nd „	600 „	400 „	
3rd „	500 „	300 „	

And the *artillery stores* to be supplied in reference to those quantities, as shewn in the annexed Tables A. and B., for each gun, howitzer, or mortar, exclusive of field-pieces, for which see 'Equipment of Field Artillery.'

TABLE A.—Appendix I.

Proportion of the principal Artillery Stores necessary to sustain a Siege.

STORES.	Number per piece. Guns.	Howitzers.	Mortars.
Blocks, Carts, } hand or trench	1/20	1/20	1/20
Carriage, devil	1/20	1/20	1/20
Cartouches, leather, large	1	1	1
Clippers, portfire	1	1	1
Flints, musket	10	10	–
Gyns, large, complete	1/20	1/20	1/20
Handspikes, common	6	4	4
Handspikes, roller for every traversing platform	2	–	–
Hand crow-levers, 6 feet, Iron crows, $5\frac{1}{2}$ feet, } a small proportion to each battery	–	–	–
Hammers, small claw	1	1	1
Heads, rammer	1	1	1
Heads, sponge	1	1	1
Horns, powder	1	1	1
Hambro' line, skeins	½	½	–
Iron, flat, round, } lbs.	10	–	–
Irons, priming, long (sets)	1	1	1
Linstocks, with cocks	1	1	–
Ladles, copper, with staves	1	–	–
Locks, detonating, with laniards and covers	1	1	1
Punches for vents	1	1	1
Ropes, fathoms (to correspond with blocks) Vide 'Block.'	2	1	–
Ropes, drag or harness, 1 to 10 pieces	1/10	1/10	1/10
Spikes, common	2	2	1
Staves, spunge, spare	1	1	1
Sponges, with staves complete*	2	2	2
Spun-yarn, lbs.	1	1	1
Screw jacks	1/10	1/20	–
Tampions	–	–	1
Thread, pack, lbs.	½	½	½
Tools, armourers' or forge, sets	1/50	–	–
Tools, collar-makers', sets	1/100	–	–
Tools, intrenching, sets	1	1	1
Tools, laboratory, sets	1/20	1/20	1/20
Tools, wheelers', sets	1/60	–	–
Wadhooks, with staves	1	–	–
Waggons, Flanders	1/10	–	–
Waggons, sling	1/20	1/20	1/20
Wads, junk	700	–	–
Wood, felloes, spokes, } spare No.	4	4	–
Wood, oak, cubic feet	2	2	2

* The like number of rammers with staves must now be demanded.

TABLE B.—APPENDIX I.

Proportion of principal Laboratory Stores for the Armament of Places.

STORES.	Number per piece. Guns.	Howitzers.	Mortars.
Shot, round	600	–	–
Shot, case, common	70	70	–
Shot, case, spherical	100	100	–
Shot, grape	100	–	–
Shot, pound (rounds)	–	–	100
Wooden bottoms for pound shot	–	–	100
Carcasses, round, fixed	–	–	10
Cartridges, charge flannel, or paper with flannel bottoms	600	400	–
Cartridges, bursters, flannel, common	–	70	–
Cartridges, bursters, flannel, spherical	100	100	–
Valenciennes composition (if necessary) at discretion	–	–	–
Gunpowder, large grain, whole barrels	50	30	20
Gunpowder, fine grain, ℔s.	10	10	–
Gunpowder, mealed, ℔s. (if necessary) at discretion	–	–	–
Shells, common, empty	–	500	400
Fuzes, common shells	–	600	500
Fuzes, spherical case-shot, cut, C ·3	50	50	–
Fuzes, spherical case-shot, cut, D ·4	50	50	–
Fuzes, spherical case-shot, cut, E ·5	50	50	–
Fuzes, spherical case-shot, uncut	50	50	–
Portfires	60	60	60
Tubes, detonating	1000	800	700
Match, slow, yards	50	50	50
Match, quick, lengths, at discretion	–	–	–
Augers, fuze	1/10	1/10	–
Barrels, budge	–	–	1/5
Boxes, tin, with straps, for fuzes, black	1/10	1/10	–
Boxes, tin, with straps, for fuzes, blue	1/10	1/10	–
Boxes, tube, or pockets, leather	1/10	1/10	1/10
Bags, canvass, with straps for fuzes, striped	1/10	1/10	–
Bags, canvass, with straps for fuzes, yellow	1/10	1/10	–
Compasses, pairs	–	1/10	1/10
Engines for drawing fuzes	–	1/20	1/20
Files, square	1	1	1
Funnels for shells	–	–	1/10
Funnels for loading mortars	–	–	1/5
Hooks, hand, pairs	–	1/10	1/10
Hooks, beam	–	1/10	1/10
Knives, cutting	1	1	1
Measures, copper, for powder, sets	–	1/10	1/10
Perpendiculars	–	1	1
Pincers, fuze, iron, pairs	1	1	1
Plummets, lead	–	–	1
Quadrants, brass	–	1/5	1/2
Diagonal scales	–	1	1
Saws, tenon	–	1/3	1/3
Scales, copper, with beams, pairs	–	–	1/5
Scrapers for shells	–	1	1

TABLE B—*Continued.*

STORES.		Number per piece. Guns.	Howitzers.	Mortars.
Screws for drawing corks		1	1	1
Sticks, portfire		2	2	2
Sheep skins		–	–	1
Thumbstalls		–	–	1
Tongs for placing shells*		–	1	–
Weights, brass, 4 lb. piles		–	–	$\frac{1}{4}$
Worsted, ozs.		1	1	–
Wadmilltilts		$\frac{1}{20}$	–	–
Rockets, signal		1	–	–
Rockets, parachute		1	–	–
Blue-lights		5	–	–
Light-balls		–	–	30
Laboratory materials, Antimony	lbs.	According to circumstances, as in addition to the fireworks already enumerated.		
Saltpetre	lbs.			
Sulphur	lbs.			
B^k. Dg^d. charcoal	lbs.			
Isinglass	lbs.			
Vinegar	gal.			
Spirits of wine	gal.			
3, 4, 5, and 6-strand cotton	lbs.			
Red orpiment	lbs.			
Cartridge paper	quires			
Rosin	lbs.			
Bees'-wax	lbs.			
Tallow	lbs.			
Pitch	lbs.			
Turpentine, spirits	gal.			
Linseed oil	gal.			

The Application of the foregoing Principle to the Defence of Places.

Taking the octagon of Vauban as the example, it has been shewn, in Article 'Artillery,' that the number and nature of ordnance required for that description of fortress, are

Eight 32-pounder guns for the salients of bastions		
Forty 24-pounder guns for the flanks	75 guns.	
Twenty-seven 18-pounder guns for counter-batteries		
Eight 10-inch howitzers for salients of ravelins	15 howitzers.	
Seven $6\frac{1}{5}$ or 32-pounder howitzers for counter-batteries		
Twenty-four 13-inch mortars for the bastions		
Eleven 8-inch mortars for the outworks	45 mortars.	
Ten $6\frac{1}{5}$ mortars for the covert-way		
Field-pieces for sorties, &c.	15	
Total	150	

To this provision may be added a certain number of light and heavy rockets, say three of each to every piece of ordnance.

The number of artillerymen assigned to each piece for the octagon will be as before proposed to each piece.

* The apparatus for carrying and handling hot shot forms part of the furnace equipment.

75 heavy guns	× 7	= 525	artillerymen.	
15 howitzers	× 6	= 90	„	
45 mortars	× 5	= 225	„	
15 field-pieces	× 8	= 120	„	
Total	.	960	rank and file:	

an apparently large number, but when divided into three reliefs it will be found inadequate, and men of the Line will be required to be attached to the Artillery, to the extent of as many more, to assist in the various duties of that Service. (See Appendix IV.)

The quantity of ammunition required for the defence of an octagon will be found to exceed 3000 barrels of 90 lbs. each.

This arrangement in the application of artillery is without reference to the duration of the defence, which is contingent on circumstances which are not to be foreseen; therefore the maximum quantity is given for that fortress, and provided for in Tables A. and B.

The *Artillery operations* in the defence of fortresses usually commence on the investment, when the fire of the guns and howitzers mounted in the salients, and the mortars in the bastions, should endeavour to destroy the besiegers' *dépôts*, *parks*, and *encampments;* and at this period the heavy rockets should keep up a constant fire during the night for those objects.

The second and most important period in the artillery operations is from the opening of the trenches until the besiegers' artillery has full play, which period may possibly be protracted from forty-eight hours to a week under favorable circumstances by destroying the besiegers' batteries and dismounting their guns; for during this time the artillery of the place is paramount and undisturbed by the fire of musketry or guns.

See Plate, Defence of Fortresses.

The Plate shewing the distribution of artillery for the defence of places will give an idea of the power of an octagon fully armed, which, if used with vigour and activity, will take some time to be overpowered; and as the position of the enemy's batteries is certain, during their construction the whole force of the artillery of the place and the light rockets should be used, and the latter being laid and fired from the crest of the glacis, a constant fire may be kept up so long as the covert-way is tenable.

The next period in the artillery operations for the defence is after the fire of the besiegers' batteries is in full force; for notwithstanding the immense resources of the place, that will eventually occur, and the guns be dismounted and parapets destroyed; then the ordnance in the salients and the covert-way should be withdrawn and placed in the collateral fronts, the dismounted pieces removed and every thing made snug, and the ammunition economized for the last effort,—the attempt to destroy the breaching batteries and impede the final advance of the besieger by a new disposition of the flank defences and the employment of the heavy mortars as pierriers.

It is not necessary here to make out the minutiæ of Artillery duties during a siege, being a question of detail and of economical arrangements of stores, ammunition, and laboratory duties, and the judicious distribution and employment of the men, which will fall exclusively on that department.

APPENDIX II.

PROPORTION OF OFFICERS OF ENGINEERS, SAPPERS AND MINERS, AND ENGINEER STORES, NECESSARY FOR A SIEGE.

In regulating this proportion, some data must be fixed suitable to all places and to

all circumstances: classifying the fortresses under the following heads will be most suitable to our Service:

Maritime fortresses . . .	First class, or most considerable. Second „ or small places.
Fortresses in the interior, or on land frontiers . . .	First class, of 10 sides and upwards. Second „ of 6 to 10 sides. Third „ of 4 to 5 sides.

And the arrangement for calculating the number of officers and men must be separated from that for the requisite quantity of stores; the latter being regulated on the maximum quantity necessary.

The proportion of officers and men may be calculated upon the same rule as that which provides for the Artillery and men of the Line in Appendix I. and IV., viz.: 1st, for the ordinary duties of a fortified place; and 2nd, in the event of a siege.

For the first it is proposed to assign

To the second class maritime, and third class land fortresses . .	3 Officers of Engineers, and 1 company of Sappers and Miners, including Officers.
To the first class maritime, and second class land fortresses . .	5 Officers ditto, and 2 companies ditto ditto.
To the first class land fortress . .	7 Officers ditto, and 3 companies ditto ditto.

And on the probability of a siege, that force to be doubled.

Under the latter circumstance it is usual to divide the whole into three reliefs, which will be found then generally inadequate; and a certain number of artificers, usually found in regiments of the Line, will be attached to the Engineers, which is alluded to in Appendix IV. in calculating the necessary strength of the garrison.

The proportion of stores, &c., necessary for a siege.

These essentials and indispensable resources to the Engineer department are threefold,—tools, stores, and materials; and the quantity necessary will be regulated by different rules; the first by the strength of the garrison, the second by the quantity of artillery, and the third by the nature of the fortress,—observing that the works are presumed to be in a proper state of repair.

TABLE A.—Appendix II.

List of Tools necessary to sustain a Siege, calculated upon half the maximum Garrison, although only one-third or one-fourth could be employed: this allows for waste and accidents. (See Appendix IV.)—Per 100 men.

Adzes	3	Jumpers, smallest	2
Assortment of Carpenters' tools	1	Levels, Masons'	2
„ Miners' „	½	Miners' needles, of sorts	3
„ Masons' „	¼	Sap forks	3
„ Smiths' „	⅛	Saws, hand	10
Axes, felling	10	„ cross-cut	5
„ pick	70	„ pit	3
„ broad	3	Shovels, long	10
Barrows, hand	10	„ common	100
„ wheel	20	Spades	50
Bill-hooks	60	Spare helves	200
„ hand	10	Scrapers, Miners'	1
Crow-bars	6	Sledge-hammers	10
Cart, hand	1	Tamping-bar	1
„ single horse	1	Screw or lifting jacks	1
„ timber (or devil)	1	Grindstones, large	3
„ forge	1	Scaling ladder, lengths of 10 feet	10
Jumpers, long	2		

TABLE B.—Appendix II.

List of Stores for the Defence of Fortresses, calculated upon the quantity of Artillery.
(See Appendix I.)

		No.
Chevaux-de-frize, of 10-ft. lengths, calculated for 15 pieces of ordnance		15
Fascines, revetting, 18-ft. . .	,, ,, ,,	500
,, choakers	,, ,, ,,	10
,, mallets	,, ,, ,,	10
Gabions	,, ,, ,,	350
Nails, spike, 5-inch	,, ,, ,,	200
,, ,, 7-inch	,, ,, ,,	100
,, ,, sorts	,, ,, ,,	1000
Platforms, Madras	for ordnance in store for second period of attack	12
,, mortar	for ordnance in store for second period of attack	6
Sand-bags	,, ,, ,,	12,000
Rope, coils 3-inch	,, ,, ,,	1
Rope, coils 4½-inch	,, ,, ,,	1
Iron 2e blocks to suit ditto . .	,, ,, ,,	1
Ditto snatch ditto . .	,, ,, ,,	1
Timber for magazines	cubic feet	350

Vide 'Block.'

TABLE C.—Appendix II.

List of Materials for the Defence of Fortresses, according to their nature in the proportion of each Front of Attack.

	Wet ditches, and ample bomb-proofs.	Dry ditches, countermined, and ample bomb-proofs.	Dry ditches, not countermined, and ample bomb-proofs.	Without bomb-proof.	One-half bomb-proof.	One-third bomb-proof.
	per front	per front	per front	per front	per front	per front
Gunpowder, barrels	5	100	10	,,	,,	,,
Galvanic apparatus	1	4	2	,,	,,	,,
Iron, round, lbs.	50	50	50	50	50	50
,, flat, lbs.	100	100	100	100	100	100
Pontoons, Blanshard's, large . . .	50	,,	,,	,,	,,	,,
,, ,, small . . .	50	,,	,,	,,	,,	,,
Portfires	1	20	2	,,	,,	,,
Plank* 3″—ft. sup[l]., for repair of bridges	100	50	50	,,	,,	,,
blindages	200	200	200	200	200	200
with countermines	,,	150	,,	,,	,,	,,
without do.† .	,,	,,	4500	,,	,,	,,
Timber—ft. cube, repair of bridges . .	100	50	50	50	50	50
,, blindages † .	,,	,,	,,	5000	3000	2000
with countermines	,,	50	,,	,,	,,	,,
without do.† .	,,	,,	450	450	450	450
repair of palisades,† stockades, barriers, and gates . .	250	250	250	250	250	250

* This 3″ (the most generally serviceable) stuff to be cut into 1½″ for mining purposes.

† These quantities can only be considered as approximate and probable. The whole character of these Tables is rather that of reminders and general assistances; attempts at precision would be ridiculous. It must be remembered that the above quantities are for one front only; when multiplied by the number of fronts in the whole polygon, they will probably insure a sufficiency for those attacked.

The Engineer operations in the defence of places are usually—

First, previous to the investment, to provide a sufficient quantity of fascines, gabions, and timbers, in the proportion given in Tables B. and C.; and in respect to masonry bomb-proof cover, the complement should be supplied as follows:

Third class land fortresses, and second class maritime	Two-thirds of the garrison, and all the ammunition and stores, should be in the masonry or blindage proof cover.
Second class land fortresses, and first class maritime .	One-half of the garrison, all the ammunition, and two-thirds of the stores.
First class land fortresses .	One-third of the garrison, all the ammunition, and one-third of the stores.

This rule is based upon the principle, that the larger the fortress, the greater the difficulty to bombard it effectually; and upon the consideration likewise, that maritime places, when besieged, are liable to bombardment from gun-boats and vessels of war.

The second description of duties usually assigned to the Engineers lie in the requisitions of Artillery, Commissariat, and Medical Departments, which are made on them when a siege is probable, consisting of side-arm-sheds, fitments for stores, expense magazines, and additional security to the powder magazines for the artillery. The Commissariat usually require ovens and stores to be secured and fitted; and the Medical Department, a proper provision and safety for the sick and wounded. These demands are in addition to those adverted to in the Instructions, for rendering the defences complete. Hence it is assumed that the fortress is in a perfect state of defence, and requiring only those works necessary after the investment.

When then this event has been consummated, and the front of attack understood, the Engineer operations should be confined (all the previous wants being supposed to be completed) to the construction of traverses and parados, cutting and revetting the embrasures, and laying platforms for the artillery which will now be brought into action: the artillery for immediate defence hitherto only having been used against the early period of attack, that necessary to sustain the brunt of the siege should be brought from store, and placed in battery on the fronts of attack and the collateral fronts. The execution of these works will fully occupy one-third of the Engineer department night and day to prepare the whole for the artillery by the time the first parallel is completed, and the emplacement of the enemy's batteries begun.

After these defence batteries are completed, and during the contest for superiority between the artillery of attack and defence, which may last, as it has been before suggested, from forty-eight hours to a week, the Engineers should prepare such resources as circumstances dictate in countermines executed at the moment, tracing such intrenchments as may be necessary to the covert-way, outworks, and front of attack.

The third important Engineer operation is, (after the destruction of the parapets, palisades, guns, and carriages of the besieged,) when the debris has to be cleared, parapets to be repaired, new platforms laid, fresh embrasures cut, blindages and bomb-proofs to be re-covered and repaired, new traverses constructed: these will probably be executed under a heavy fire of guns, mortars, and small arms; advantage, however, must be taken of the dark, when the besiegers are equally well employed. During these operations, the countermines and intrenchments should progress, so that one-half of the Engineer force will be in full employ.

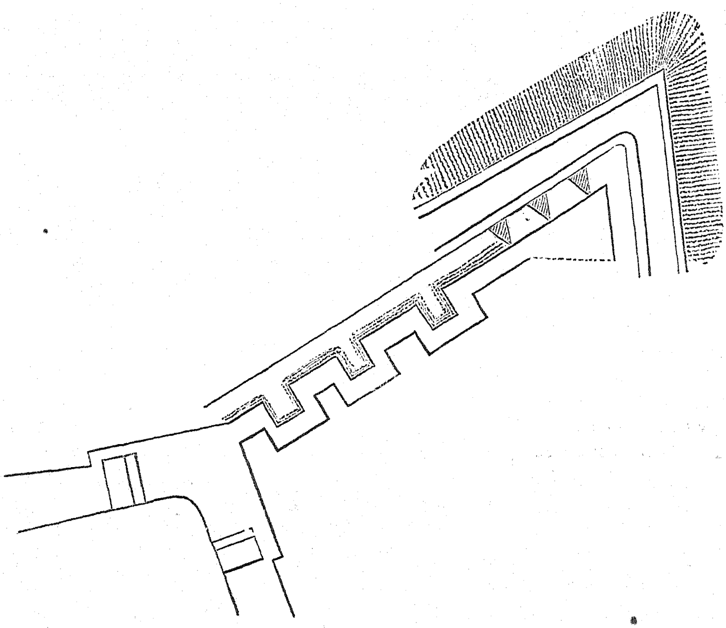
After this there will be another lull, except to those employed under ground and in the intrenchments.

The next period, the most interesting to the Engineer, is when the defence wholly depends upon his exertions (the artillery for defence now being passive), and compre-

hended between the advance from the second parallel to where the breaches are effected. It is during this time that well-directed sorties, conducted and executed by the men employed under the Officers of Engineers, can protract the advance, and thus turn the defensive into offensive operations: these sorties, frequent and in small numbers, should be accompanied by workmen with the means of setting fire to the gabions and fascines, sap forks for upsetting the sap, and each man with two or three nails to spike the ordnance, if the sortie should be sufficiently successful.

Want of skill in the Besieger, or other favorable circumstances to the defence, may render the counter-approach practicable, in the manner described in the figure below; and if a few fougasses (by placing boxes of powder or large shells) are employed, they will render a lodgement of the enemy difficult.

Diagram of a Counter-approach—for a Collateral Front.



Among other resources at this period of defence, is the application of mines prepared after the investment, the place not being countermined as explained in Appendix V. For the regular system of defence by countermines, see 'Military Mining.' The chicanery of water manœuvres when the ditches can be filled at pleasure, sorties, counter-approaches, and mines, must be guided by opportunity and local resources, rather than by any prescribed rules on paper: and if the attack is in force, all that can be expected is to protract the defence, and render the relief of the fortress possible; or, if the attack is weak, to oblige the enemy to raise the siege.

If none of the above are available, and the breaching batteries are established, the final question of defending the breach has to be considered. Without permanently intrenched bastions, the only effectual means are, when the ground within the front attack is favorable, or when strong buildings immediately in rear of the breaches can be barricaded, and the enemy obliged to bring their artillery across the ditch: with these advantages, the breaches may be defended by means of fougasses, powder-

bags, grenades, live shells, and fire-barrels filled with pitch and fagots, rolled down. Large fires have been also successfully adopted under peculiar situations, to sustain an assault on the Body of the Place.

It has been observed that the Instructions drawn up by Carnot might have the effect of giving an undue value to fortified places, and yet they should not be deemed as mere time-pieces, destined to go so many days or weeks; for that Author no doubt considered that sieges were frequently undertaken with insufficient means, tempted by the neglected state of the works, or weakness of the garrison, and that an efficient siege equipment was an affair of immense magnitude, difficult to transport. However, it is when a fortress is attacked with inadequate means, that an enterprising Governor, assisted by a skilful Engineer, can take advantage of it, and convert what was deemed weak into one far above its supposed strength, as occurred at Burgos when defended by the French, and at Tarifa when defended by an Anglo-Spanish force.

ide 'Battery.' l. II. figs. 6, 7.

It has been omitted to provide for mantlets for the embrasures; for after the establishment of the third parallels, it will be difficult without them for the artillery-men to work the guns. Sand-bags should be piled on the crest of the parapets to cover the marksmen, who, even after the works are destroyed, can place themselves in the ruins, and, covered by a few sand-bags, keep up a heavy fire.

In the defence of the Castle of Scilla (Sicily) by the British troops, the masonry parapets were levelled; yet a few good marksmen used to creep upon their bellies, and waiting the effect of an 8-inch iron mortar (which could not be silenced), they poured in their fire on the people as they ran out of the battery, who always dispersed on the appearance of the shell in the work.

APPENDIX III.

PROVISIONMENT OF FORTIFIED PLACES.

The quantity of provisions or commissariat stores necessary for a siege is one of the first essentials, and the supply for the inhabitants should be considered, as well as provision for the garrison; for notwithstanding every means are taken to induce the families to provide for themselves, their resources are found inadequate, and they are eventually supplied from the public stores.

Perhaps it would be better to take this into consideration at once, and provide a minimum ration for each adult of one pound of flour or meal.

In respect to the garrison, as it will probably be after the investment left wholly to the resources in the public stores, and as the duties will be very severe, it should be placed nearly upon the allowances given to Her Majesty's Navy when at sea.

Table of Provisions for Troops necessary for a Siege for 56 *days, for* 100 *Men.*

		ARTICLES.		Bulk in cubic feet (allowing for barrels, &c., &c.)
		Flour or meal	2200 lbs.	76
		Biscuit	5600 ,,	358
	or	Beef, salted	5600 ,,	216
		Pork	5600 ,,	202
	or	Rice	2200 ,,	70
		Peas	1400 pints	54
		Cocoa	700 lbs.	41
		Sugar, soft	525 ,,	14
	or	Spirits	1400 pints	56
		Wine	5600 ,,	224
		Vinegar	200 ,,	8
Forage.		Hay for 20 horses for 56 days	7 tons	4000
	or	Barley	7200 lbs.	160
		Oats	7200 ,,	250
		Straw, ditto as hay	7 tons	4000

	ARTICLES.			Bulk in cubic feet.
Fuel for cooking only.		Wood		1280
	or	Coals	7 tons	350
	or	Turf. .	(Kish of 20 cub. ft. = 100 lbs. coal)	3000
		Oil	40 gallons	4
		Candles	40 lbs.	3

The bulk of these articles is given, in order that bomb or splinter-proof covers may be provided for the combustible, and adequate stores for the incombustible.

APPENDIX IV.

Strength of Garrison, Quantity of Ammunition, Arms, and Stores, necessary for a Siege, exclusive of Artillery, Engineers, and Commissariat, provided for in Appendixes I. II. and III.

The authorities given are so vague and unsatisfactory, that it is conceived preferable to form data upon considerations framed from experience, as well as the usual rules given upon these subjects.

In respect to the *strength of the garrison*, the principle proposed for the supply of artillery seems adapted also for the contingent circumstances to which a fortress is liable. The force required, therefore, will be regulated, first, for the immediate security of the place, and then the number to sustain a siege: this arrangement avoids the necessity of shutting up a considerable body of troops without an immediate object.

It is proposed to appropriate *per bastion*, or each front of the fortress, first, for the immediate security of each place, 350 infantry rank and file.*

10 cavalry ,,
60 artillery ,,
20 sappers ,,

440 per bastion.

And double that number to sustain a siege for the fronts susceptible of attack; for in maritime places the former proportions will be probably adequate for the enceinte generally.

The latter force to be thrown into the place by the General commanding the army when there is any probable risk of its having to sustain a regular attack.

Of the two evils, of having garrisons not fully adequate for his fortresses, or having a large body of troops unnecessarily pent up within them, the General commanding will find the second very likely the greatest.

The quantity of ammunition, arms, and Quarter-Master-General's stores, are proposed for the maximum forces in the following proportions:

Surplus arms, 1 for every four men.
Wall-pieces, 10 for every front of fortification.
Ammunition for ditto, 500 rounds each wall-piece.
Musket-ball ammunition made up, 500 per man.
Lead, 10 lbs. per man.
Cartridge paper, $1\frac{1}{4}$ quire.
Hand-grenades, 10 per man.
Gunpowder in barrels, $2\frac{1}{2}$ lbs. per man, (exclusive of wants of Artillery and Engineer Services.)
Barrack bedding, 1 set per man.

* This provides for the probable requisitions from the Artillery and Engineer Services.

Shoes or boots, 3 pairs per man	These are in addition to those in possession of the troops.
Spare haversacks, ½ per man	
" great coats, "	
" canteens, "	
" blankets, "	
" camp kettles, 1 for every 20 men	
Tools, felling axes, 1 for every 16 men	Exclusive of Engineer stores.
" bill-hooks, "	
" pickaxes "	
" shovels, "	
" hand-saws, "	

APPENDIX V.*

MINING OPERATIONS WHICH MAY BE UNDERTAKEN IN THE DEFENCE OF FORTRESSES WITHOUT COUNTERMINES.

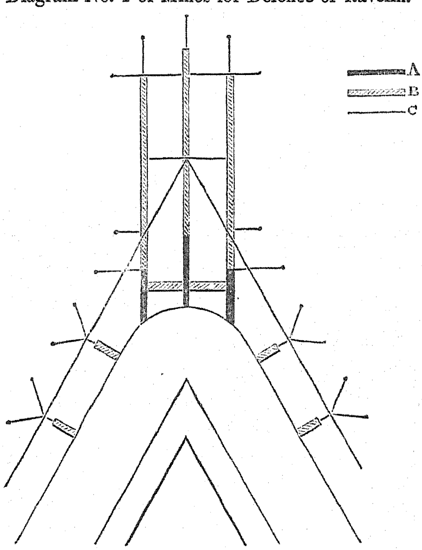
Supposing a decagon entirely without countermines, it will now be explained what mining operations may be executed to strengthen the place and protract the defence.

1. For this description of fortress there should be, at least, 72 good miners, who, being subdivided into brigades of two each, so as to afford the necessary reliefs, will be reinforced by four men of the line to each brigade.

2. In commencing work, the fronts most likely to be attacked should be chosen; but if all fronts are equally liable to be attacked, (which case will be supposed by way of example,) all must be provided with this means of defence.

3. This question being decided upon, and presuming that the investment will last 10 days, a brigade of miners should be placed on the capital of each ravelin, and three principal galleries executed, as described in the diagram No. 1, and extended as demi-galleries to about 60 yards from the counterscarp, which will bring them to where the listeners or branch galleries should commence, at least 20 yards from the salient angle of the covert-way.

Diagram No. 1 of Mines for Defence of Ravelin.



A. Principal gallery. B. Demi-gallery. C. Branch.

* Taken from 'Manuel pratique du Mineur,' by Villeneuve.

4. As soon as the trenches are opened and the fronts of attack known, the brigades of miners will unite from this period until the cavaliers of trenches are established on the glacis, which may be conceived to extend to 12 days more, and complete the galleries and branches as follows:

5. For the ravelins, the galleries may be prolonged as branches or listeners 30 yards, and externally 10 yards right and left: these, when completed, will afford for each of the collateral ravelins of the bastion attacked—

Principal gallery,	26	yards,
Demi "	178	"
Branches	255	"

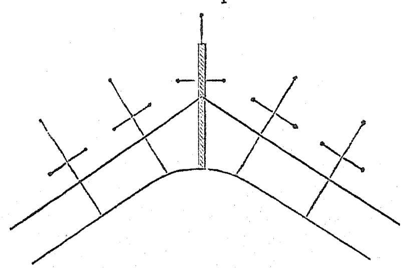
which may be easily excavated in 12 days.

6. For the bastion, there will be sufficient miners left to work at the mines to be placed under the site necessary for the breaching batteries of the enemy, the branches of which will amount to about 220 yards—one portion being placed on the capital, and two on each side, so as to include the counter as well as the breaching battery; and it will require 14 days to execute these works. See Diagram 2.

7. It may be observed, that if the bastion attacked is very retired, or rather, if well covered by the collateral ravelins, the mining operations may be confined to the salients of those ravelins; but if the contrary is the case, then the glacis of the bastion must be principally provided with this species of defence.

The probable expenditure of gunpowder will be about 7 barrels of 90 ℔s. for each mine or explosion.

Diagram No. 2 of Mines to be placed in Glacis of Bastion.



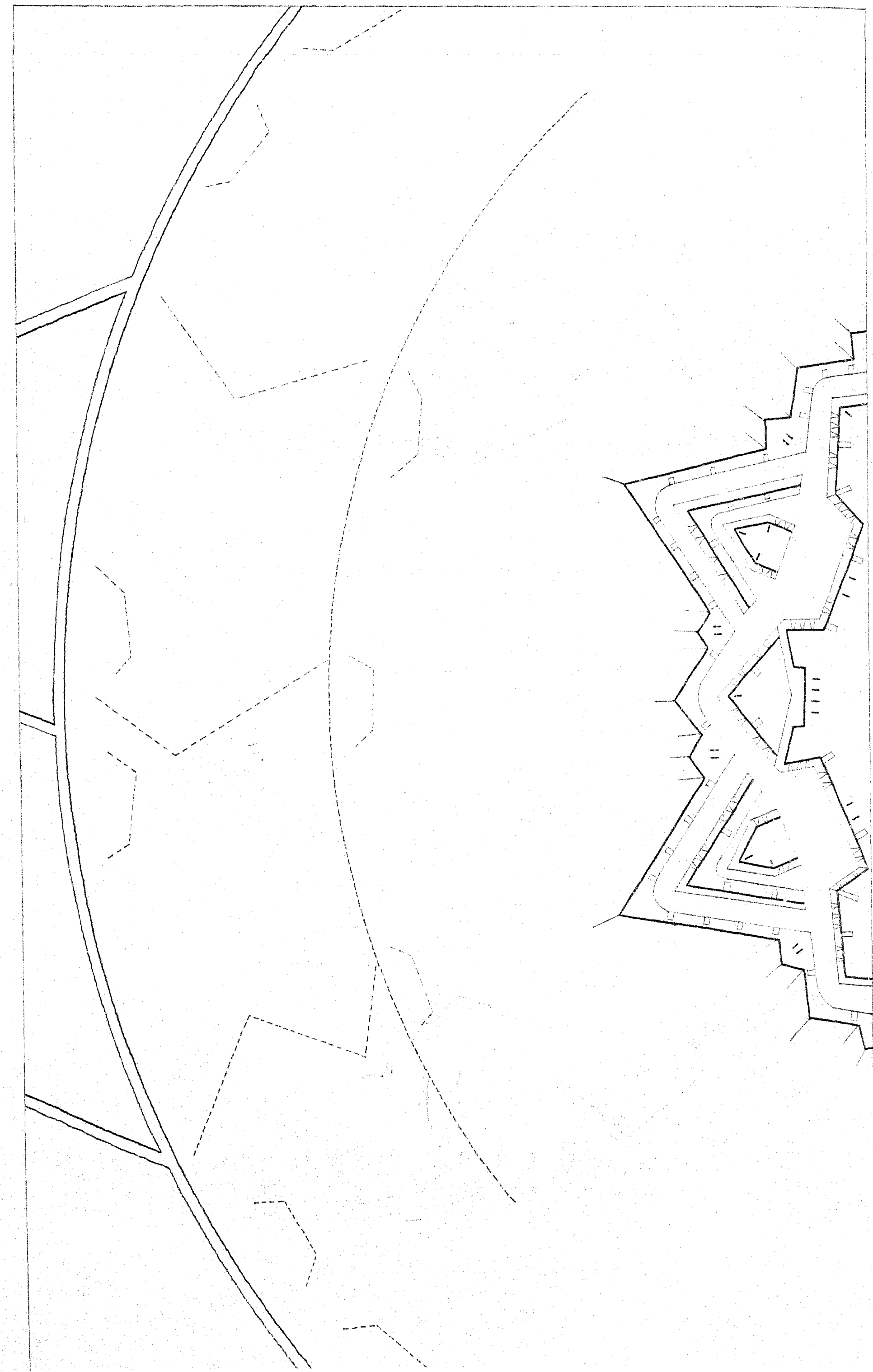
Memorandum.—For putting fortresses which have been neglected, or allowed to become unfit for defence, into a state to resist a siege, as adverted to in Carnot's Instructions, *vide* 'Reparation of Fortresses.' G. G. L.

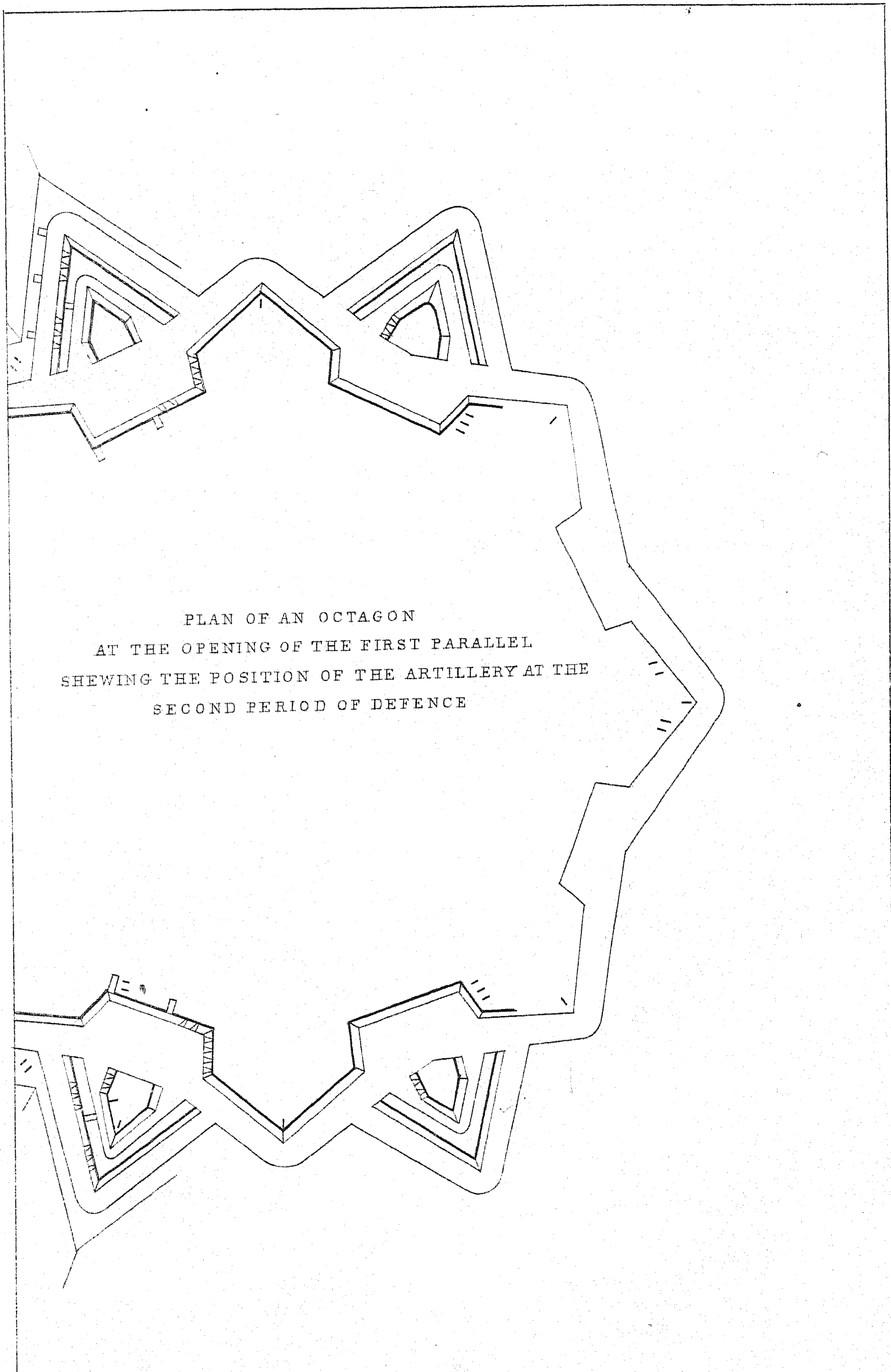
DEFENSIVE PRECAUTIONS.*

When a fortress is on the point of being invested by an enemy's army, the Governor, in order to anticipate the military reconnoissances of the hostile General, and obstruct the Engineers taking measures for opening the trenches, may draw from his own military stores, or by requisition from the merchants and shopkeepers in the town, a sufficient number of pieces of linen, calico, flannel, red baize, &c., to mask the capitals of bastions and the points which would be taken for opening the first parallel, causing these, under the direction of his Engineers, to be stretched

Masking works.

* Fragments by Lieut.-Colonel C. Hamilton Smith, K.H.





PLAN OF AN OCTAGON
AT THE OPENING OF THE FIRST PARALLEL
SHEWING THE POSITION OF THE ARTILLERY AT THE
SECOND PERIOD OF DEFENCE

Chains of A
vanced sent

along ropes, held up by means of poles along the glacis; where those long unexpected lines of white, green, or red, set so as *not* to correspond with the angles of the fortifications, will tend greatly to throw the opponent into error, and probably retard the trenches being opened for several days. These stripes of cloth should be altered more or less every night; in some places a second line of them may be raised from the points of the bastions, and carried obliquely to the curtains; and all the light troops acting as skirmishers should lie out on the glacis, as far in advance as possible, to prevent all nearer access by the enemy's scientific department and staff officers. Hostile shot will not very readily cut the ropes, and striking the cloth will not unmask the objects behind: but in order to leave less chance of the cloth being thrown down, each pair of poles fixed in a × shape should have the rope securely knotted, and they should not be more than fifteen yards asunder.

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ries.

When a General invests a fortress, the commanding Engineer, though he may be materially impeded by the foregoing precautions, must not, however, suffer the Besieged to send out intelligent non-commissioned officers to creep in the night to the marks laid down by his Officers for the direction of the trenches, and change or withdraw them. He must not suffer patrols to come out, and endeavour to intercept all communication from within and without the place passing through the investing posts. Small but vigilant guards should for this purpose keep the most strict watch in the rear of the army, particularly at all bridges, fords, and narrows; the sentries keeping perfect silence, unless when challenging, and then it should be done with no more voice than is necessary for the purpose.

As the Engineers within a besieged place are fully aware of the weakest points in their defensive system, so they must be expected to be most jealous about them and watch them with the utmost anxiety. In forming therefore the investment, it may be as well to give them uneasiness or even expectation that the Besieger has mistaken the weakest part, by affecting to push cautiously forward such light troops as are destined to approach nearest to the glacis on those points which are only of secondary consideration: but the true front to be attacked should be covered by riflemen, who, formed in chain by fours at the distance of twelve or fifteen yards from each other, advance as soon as it is sufficiently dark to prevent being distinguished by the enemy; officers and serjeants keeping even with the line, and the connection of the links being maintained by the slowness of the movement and the occasional sound of a light *tap* upon the pouch of the right-hand man of each link passing from right to left, and then back again. On coming within the range of grape, or when the commanding Officer judges it to be time, they will receive a similar low preconcerted signal to drop on their hands and knees, crawling forward to within two hundred yards of the glacis, when *three taps* to halt will be given by the commanding Officer, and all are to remain (in their great coats) as near the ground as possible, excepting one in each link, who sits upright, or stands if there is cover, until relieved by his companions. The officers and non-commissioned officers watch on the flanks, or crawl from link to link. None are permitted to smoke, or speak louder than a whisper; none to quit the links on any account towards the front; the Officer visiting the line not to be challenged, nor to respond but by preconcerted taps on the pouch, the powder-horn, or other token: none to challenge persons coming from the town until they have passed through the line of chain, and then they must be followed by a serjeant with two or more men taken from the nearest links, who in a low voice will desire them to surrender without making a noise, on pain of instant death. The person, deserter, spy, or messenger, must then be carefully watched, lest he should drop letters, &c., led directly to the rear, and given in charge at the first

post, and there searched, to be dealt with as may be ordered by the Officer in command of the trenches. But persons coming from the rear towards the town, must be stopped, if possible, before they reach the chain, and, if strangers, treated like the first mentioned.

Should a patrol of some strength come on and pass through the chain, a sufficient number of links, making eight, ten, or twelve men, will collect, follow it, and cut off its retreat, if possible, without noise, and in no case shew more of the chain than is necessary. Should light-balls be thrown out, all must lie down, immoveable, till their fire is spent. Just before dawn, the chain will draw further back, but not retire, because sorties are likely to be then made. Therefore several non-commissioned officers should remain behind, lay an ear to the ground, listen attentively, or even crawl up to the palisades before they fall back. Of course the troops in the trenches are then under arms. In this manner the front of attack will be thoroughly watched, and, with sufficient light troops similarly instructed, not a single hostile individual can enter or quit the place.

Defensively.

When the case is reversed, and the fortress is to be defended, it follows that all the instructions must be taken in a contrary manner; and the rifles in a place besieged, if trustworthy, should be kept as long as possible beyond the glacis with similar precautions.

These remarks are intended for the Engineers, who may often find the troops employed on the occasion of expeditions and distant sieges unprepared by any previous instruction on this head, and therefore will then be obliged to cause some preparatory drill to be given to the troops at hand, so that they may effect the purpose intended with order and punctuality. Commanding Officers of battalions will be able to tell whether their light companies are taught the above method of enclosing enemies' fortresses, or of watching posts of importance in this manner.

At Gertruydenberg, during the late war, where the escarps were of earth, and unprotected by fraises, the writer of the above rendered them inaccessible during the winter by throwing water over them, so as to encrust the whole exterior slope with a sheet of ice.

At the siege of Dantzig, in 1813-14, on the other hand, the ditches were prevented from being frozen by row-boats being kept constantly moving up and down.

DEFENCE OF COASTS.*

In offering suggestions for the defence of open shores, harbours, and rivers, it is necessary to advert to the several securities required for these situations, whether from predatory attacks, or from those of a more serious character, directed against an asylum for commerce, a dockyard, &c.

For the first, extensive works are seldom required; but for the latter, it may be proper to afford protection for single vessels or fleets according to circumstances, in addition to the security given by the roadstead, river, or harbour.

GENERAL CONSIDERATIONS

are,—those of localities, whether the point to be fortified is near or distant from the principal towns or naval ports; if the access to those places from the landing is good; if through defiles easily defended, or an open country. If the

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* By Colonel Lewis, R. E., with notes from Colonel Harding, R. E.

point to be defended is remote, the question may be confined to the local damage probable, or whether it may serve as a harbour of safety to trading vessels, particularly to the coasting trade; or the site may be so remote and the approaches from it so difficult as to render any expensive works superfluous: or the consideration may be that the point is favorable for a debarkation to assist a population hostile to the existing government, and serve to secure ulterior proceedings to an enemy.

If the object should be to secure the possession of a harbour or river, the question will be, can it be forced? by this means the town or shipping destroyed, and if the hostile vessel or vessels, having forced the harbour or river, can return by the way they came, or by another outlet; or, having effected an entrance, may land, reduce the defences, and accomplish the object of attack, without further risk from the batteries?

In selecting sites for coast defences, the means of supporting the works by a moveable force is of importance, either by armed steamers and gun-boats, or by columns of troops whose position is fixed at some central point in the interior. Railroads forming an auxiliary in the conveyance of troops, with this assistance, a central point at 60 miles radius would form a good support; (without railroads it should not exceed 15 miles from the central position;) so that intelligence may be conveyed on railroads by the electric telegraph, and the support afforded in a few hours.

The composition of moveable columns of support to the coast batteries may be from 500 to 5000 of all arms, in proportion of seven-tenths infantry, one-tenth cavalry, and two-tenths artillery, the latter being an essential arm to oppose the debarkation of troops; the strength of the force depending upon the probable object of an enemy, as well as on what power may hold the maritime supremacy of the adjoining sea, and the proximity to an hostile armament.

Possible causes and objects of attack may be, conquest or the destruction of commercial ports of more or less value, the naval arsenal, or considerable manufacturing towns,—the possession of the principal dépôt, or capital of the State or Dependency; or taking advantage of the weakness or absence of troops: these possible contingencies should be carefully considered in distant stations and colonies, and the various questions alluded to above, in order to economize the resources of a country, and prevent an unnecessary dislocation of the forces.

THE NATURE OF WORKS MOST SUITABLE FOR COAST DEFENCES.

The instructions of Napoleon upon this subject are applicable to this point, as there is no fixed principle for the construction of works for the armament of coasts, and the question gives rise to perpetual discussions on which he has decided.

"1. That works of the first class should be assigned for the security of the entrance of a principal harbour for ships of war, be well armed, their gorges protected by a masonry barrack as a keep, capable of bearing upon the summit four pieces of ordnance and accommodation* for 60 men, with their provisions and stores and powder magazine, so as to be secured from a coup-de-main."

The battery should have a reverberatory furnace for heating shot.

"2. Batteries required for the security of harbours and roads used for commercial purposes should be of the second class, and also have at the gorge a keep in masonry,

* In the formation of batteries regard should also be had to the probable number of men that may be obtained to serve them. Five men are usually allowed to each gun, but as assistance can generally be obtained from the Line or the local population, the calculation may be grounded on two artillerymen for each gun likely to be in action at the same time. As sea batteries are kept in a state of readiness for immediate action for years, attention should be paid to secure dry cover for the ammunition, stores, and side-arms; and the guard-room and barrack secured from surprise.—G. J. H.

and sufficiently strong to bear two pieces of artillery, having accommodation for 30 men, with the necessary magazines."

"3. Finally, for batteries required at isolated points, they should be of the third class, and have a masonry work at the gorge capable of carrying a carronade, having accommodation for the men and magazines, but without counterscarp or covert-way."

The *construction* of coast defences will be treated of in the second volume. In the selection* of the site of coast defences the following points are to be considered.

1. The form of the work.
2. The height above high-water mark.
3. The distance within which shipping can approach the shore.
4. The quantity of ordnance necessary, and their nature.

1. The form or shape of coast defences, if not decided by the locality, should be regulated by the object of defence: if to dispute the passage† into the river or harbour, or roadstead or bay, or anchorage, the face of the work will be necessarily perpendicular to the approach, so as to rake the vessel as she advances and recedes, taking care, as she shews her broadsides, to cover the battery as much as possible: if the vessel should remain under fire about 20 minutes, a shot furnace should be in the battery: if she can anchor within range, two or three mortars should form part of the armament, and the entrance or gorge of the battery secured by an interior work capable of containing the necessary number of men and stores.

If under 45 or 50 feet above high water, the artillery should be placed upon traversing platforms. This last arrangement requires a larger interior space, each gun or howitzer so mounted requiring, at least, 30 feet from centre to centre.

The parapets of all coast and harbour defences should be constructed of earth or some composition that will not break into dangerous splinters, except those of towers and casemates, and the circular shape of the former renders them difficult for the guns of ships to strike effectively.‡

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* In the position of coast batteries regard must be had to the anchorage, channels, banks, rocks or shoals, set of tides and currents, prevailing winds, &c., and the emplacement made to take advantage of these difficulties. These batteries should be as near the shore as possible, in order by their front, flank, and reverse fire to obstruct a landing; and by a judicious selection of sites, an enemy would not attempt it but with a superior force. If the position should be on one of the flanks of the landing place, and the work of such strength, that it could be maintained after a debarkation was effected, a coast battery of this nature would have considerable influence upon the movements of the hostile force. When a coast consists of high cliffs, broken by practicable ravines, it is seldom advisable to place the batteries on the advanced points: the guns are too high to have much effect, and they are exposed to be cut off; the defence should rather be on the beach in the first instance, and at the top of the ravines in the second.—G. J. H.

† The landing of troops is generally attempted on a beach off which the ships of war may anchor to cover the debarkation: most beaches have headlands or projecting points, from which, if not too distant, a flanking fire on them may be obtained.

These points, with this provision, should be taken up, to oblige the enemy's ships to anchor at a distance; and from these points to enfilade the lines of boats approaching the shore: as they may require a certain permanency of occupation, the works on them should be secured against surprise or assault, and armed with heavy guns, and provided to contain the necessary accommodation for men and stores, and be enclosed in the rear.

The magnitude of the work will of course depend on the importance of the point and nature of the ground.

The projecting points frequently serve to protect vessels anchoring in the bay, and, if fortified, will prevent small landings on predatory purposes, and also impede any serious attempt, and by a flanking fire support the force brought to oppose the landing. Beaches are frequently backed by sand-hills, which should be formed into parapets for infantry and field artillery, and by their rapid fire would render a debarkation difficult.—G. J. H.

‡ The parapet of a battery is so much weakened by embrasures, which also are so liable to injury, that they should not be used in coast and harbour defences except in particular cases. Traversing platforms are preferable on any height, and the difference between a gun mounted on a

2. In deciding upon what height the emplacement of a battery should be above high-water mark, 30 feet should be considered the minimum, if not casemated, and 60 feet the maximum height. But in selecting the best heights, reference must be made to the distance within which a ship of war can approach a battery: the crest of the parapet, where there is any choice, may be regulated by the effect of the ricochet fire on the vessel, if not within 2000 yards.*

See Table II.
See Appendix II.
See Table II.
See Appendix II.

In the event of vessels of war being able to approach within 800 yards, the cover to the interior of the battery must be regulated by the following depths of water.

First rates	will require	36	feet water.
Second	,,	30	,,
Third	,,	24	,,
Fourth	,,	18	,,

Steamers from 15 to 21 feet.

3. The distance within which shipping can approach a battery is of importance, as the level of the quarter-deck of 3-deckers is 26 feet above the line of flotation.

See Table II.

2 ,,	19	,,
Frigate	13	,,
Steamers	11	,,

It rarely occurs that vessels of a small class contend with batteries, however feebly armed.

If ships of war can approach very near on an equal level and above the batteries, the latter are seldom tenable unless they are casemated; and if they can anchor, the destruction of the work is inevitable: this can only be avoided by a counterguard or work in front; but the battery will be probably silenced.

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ground platform and the former is too inconsiderable to render the latter preferable as regards height; also the traversing platforms give a facility of traversing when directing a shot against a moveable object, such as a boat or ship.—(See Appendix I. on the mode of working these platforms.)

If the batteries be well constructed, the direct fire of ships has little effect, but the greatest care is requisite that the faces be not enfiladed, especially in rivers.

A battery should expose as little escarp as possible; if on a cliff, it may be scarped, and the superior slope of the parapet formed to meet it.

Coast batteries should be so constructed as to oppose a face to every point from which they may be attacked.

When the ground round the beach rises high in rocky points or slopes, consideration must be given to the height of the batteries: too great a height renders the fire of little effect, without gaining any advantages; but batteries just placed so that the guns of the ships can with difficulty be elevated to them fire with great effect, and in security.

It is a great object to direct a heavy fire on ships before anchoring, especially at the rigging, as the loss of a spar and few ropes may oblige them to anchor when not intended, and thus derange at the same time the position of all the following ships.—G. J. H.

* Batteries on the level of the sea are much used for the defence of the entrance of harbours and bays, and may be effective against small vessels or boats; but if large ships can carry deep water close in-shore, which is frequently the case in the entrance of harbours, the guns must be casemated, to cover them from the fire of the upper decks and musketry, or the embrasures arched over, so that the guns fire through portholes.

In the defence of entrances or channels, it should be an object to obtain a position so that the battery should have a cross fire, and be able to continue its fire after ships have passed; and under these favorable circumstances they should be armed with heavy calibre.

It appears advisable, when *practicable*, that sea batteries should occupy the crest of rising ground and the platforms placed on the natural soil, on the reverse of the hill, without embrasures, so that nothing but the gun itself is exposed. If such a position cannot be obtained, or the battery cannot be raised sufficiently to secure the merlons from the guns of large ships of war, the escarp should be covered by a glacis. But batteries cut out of steep banks, or ledges of precipices, or so that their elevation is considerably above that which can be given to artillery on the decks of vessels, render the interior of the battery dangerous from the splinters and débris from above, unless casemates or blindages are constructed to prevent these accidents.—G. J. H.

It is also an axiom, that vessels of war which can come within moderate range can drive the men from the battery; that between that and 500 yards they may destroy it; and within 800 yards they may silence it, when it is built à fleur d'eau, or when the upper deck guns are on the same level with the crest of the parapet. See Table II.

If depth of water permits this approach, the battery must be casemated to prevent the first; in the second and third difficulties the battery must be 20 feet above the level of the main deck of the ship of war, and covered with an epaulement, counterguard, or glacis. If no vessel can approach within 1200 yards, the height of the battery may be left entirely to localities, having the parapet 7 feet 6 inches above the terreplein, and the guns mounted on traversing platforms.

See Article 'Artillery.'

4. The number of ordnance necessary, and their nature, for the armament of a battery.

The first is influenced by localities, yet the purpose or object which the battery is to attain, is the rule by which we are to be guided. In isolated spots, one, two, or three pieces may be placed on towers when the coast is low,* which have the advantage of combining barrack and magazines and stores for ammunition, and are not open to a coup-de-main.

If the ground is as high as 50 feet and more, above the level of the sea, that description of work should be avoided, as the summit of the tower is too high, even if sunk 12 feet with a ditch and counterscarp; but a small work for two or three guns enclosed by a ditch will be preferable.

When there is a large or considerable open coast to defend, several batteries will be required to produce a cross fire, not exceeding 4000 yards from each other, each battery containing five, seven, or nine guns, according to the nature and importance of the coast to be defended.

The nature of the ordnance should consist, when there is a choice, of one or two 56-pounders, as local circumstances dictate; and the 8-inch gun of 50 cwt., and 32-pounder long gun, with a howitzer on the keep or interior work, but this last corresponding in calibre with the guns. The supply of ammunition and stores to coast batteries is usually in the proportion of 50 rounds per piece for works of least importance, and 100 rounds for the principal batteries.† See Table I.

The next point which should be considered, is that booms are necessary for the protection of harbours and rivers.—See 'Boom,' and 'Demolition' of Boom.

No battery or batteries, however strong, can stop or prevent any ship of war or steamer entering a harbour when the navigation is free and the course is nearly direct, *if she chooses her own time.* As examples—the conquest of Curaçoa is one upon a small scale, and the passage of the Dardanelles another upon the largest.

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* Large towers are expensive in proportion to their means of offence, but necessary in particular situations, as when the space is very small, or the position entirely isolated.

In regard to towers, it will be found that a battery, with the faces directed on the point required, and closed at the rear by a loopholed barrack, the whole surrounded as much as possible by a ditch and glacis, will contain more guns and men than a large tower, and at less cost.

Towers may, however, be used to great advantage in some situations, as on narrow points of shingle, or sand, or rocks, &c., or in commanding an entrance or strait when they are left to their own defence.—G. J. H.

† In the disposition of batteries, it may be well for the convenience of the Service, in the necessary supplies, to place them in masses.

Guns have been sometimes placed in every situation where a gun could be useful, without sufficient regard to the service of them, or the communications with them.—G. J. H.

APPENDIX I.

PLATFORMS.—TRAVERSING, IRON.*

The positions of these on works have been regulated by Master-General and Board's order, 9th March, 1810, with regard to iron gun carriages;—"to be placed in such parts of fortifications as are least exposed to the enemy's fire; and in sea batteries to which heavy ships cannot approach nearer than 1000 yards."† The splinters of even a wrought iron carriage, at the usual distance from each other on board ship, will destroy at least the two next beyond it.‡ Wooden platforms, as well as carriages, should always be in store to replace those of iron in case of attack; the chief merit of these last lying in economy and durability.

Figures 1, 2, 3, 4, Plates II. III., give the details of the regulation iron traversing platforms from 18-pounders to 32-pounders inclusive; § the width between the trucks of all these carriages being the same, to suit the platforms: these last "may be adapted for front, centre, and rear pivot; and are so constructed, that by moving or reversing the bar that extends from the front pivot point to the half distance between it and the rear one, and by the alteration of the legs above the trucks, they may be made to traverse in any direction; and any alteration may be made that is required in the position of a traversing point between the front and rear."—"This must be done when the carriages are put together in the Royal carriage department at Woolwich," and this point must be stated in the demands.

There are yet old gun carriages in the Service, with the trucks closer in the front than rear; and this must be seen to in receiving reports, especially from detached posts, when these platforms are required.

In addition to the above three modes of traversing, there is traversing on the *middle of the length* (not centre between trucks) of the carriage, which requires two curbs: this seems not to have been at first contemplated for iron platforms, but has been since carried into execution. This pattern must be specially applied for.

When the thickness of the parapet admits of it, these platforms are fixed with the fore end (G G, Plates II. III.) flush with the interior face of the parapet, and having a circular indent one foot deep in front: the true radius of this arc will be the distance from G to the pivot + 1 foot.

Plate III.

	Pivot at front.	Centre.	Mid-length.	Rear.
The several radii of the indent will be	3′ 7½″	7′ 6″	9′ 0″	12′ 0″

It must be remembered that the gun, when much depressed, runs a great risk of being dismounted, on recoiling, by the lower part of the muzzle catching on the interior crest of the parapet, if not raised sufficiently above it. This may be avoided when any depression is necessary, by taking care that the crest of the parapet shall be one foot below the trunnion.

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* Strictly speaking, this subject belongs to vol. ii., but it has been added to 'Defence' for the convenience of having it in the same volume as 'Artillery' and 'Carriage,' to both of which it stands closely related. For the same reason notices would have been given on Shot Furnaces; but at this moment the decision of authority respecting certain important improvements therein has not been received. Therefore *vide* 'Furnace.'

† Confirmed by M. G. and B. O., Minute on Artillery Table E., Ranges of Iron Ordnance, 22nd January, 1844. $\frac{M}{32}$

‡ Experiments at Woolwich, in 1824, on Perring's wrought iron carriages.

§ In Table E. it is stated that the 68-pounder can also be mounted on a traversing platform, but whether the platform is wood or iron is not specified; and doubts exist as to the sufficiency of the latter to stand the severe action of the guns.

"Iron gun carriages and platforms are to be coated with anti-corrosion every two years, and not painted."—*Vide* 'Anti-corrosion.'

For weights and prices, *vide* 'Carriage,' Table XV.

The different kinds of traversing platforms most likely to be required are given in Plates I. II. III. IV. V. and VI.

No regulation exists as to the proportion of wooden carriages or wooden traversing platforms that are to be kept in store in case of attack (see Note 'Artillery Table' E.): it must depend not only on the greater or less liability to heavy direct, and enfilade fire, but on the durability of the timber, which varies greatly with the climate and with the power of the material to resist weather, both as to natural capability and proper protection by seasoning and painting, as well as to the extent of exposure.

Further, in the selection of either wood or iron traversing platforms, not only such considerations as the above (which are of especial weight in tropical climates) should be taken into account, but likewise the immediate circumstances of the times, and place, which influence the likelihood of war or peace generally, particularly if under any circumstances the point may be expected to be suddenly attacked: in such instances the wooden platform is preferable, as more generally manageable, and incomparably less liable to accident: the mere fall of the heavier pieces of the iron platform is enough to ruin them irretrievably: not so the wooden platform, the repairs of which generally lie within the compass of colonial resources, and which may be made on the spot in most cases; but those of iron can only be obtained from England on demand.

Memoranda by an old Artillery Officer.—The blocks and tacles formerly used in working traversing platforms have been done away with, and thereby much of the efficiency of the platform itself, as to accurate and rapid firing *at a ship in motion*, has been lost. In reference to open batteries, these tacles were infinitely better, in this respect, than the handspike, and should always be in the hands of the artilleryman as part of the battery equipment, proper ring-bolts* being fitted for this purpose. In small towers, where the space is confined, the handspike may be preferable to the block and tacle. The gunners should be invariably drilled to load *overhand*, and thus avoid unnecessary exposure; a lock and laniard fitted, and the gun fired at the right moment in a way that never can be done when the movement is the irregular jerking one given by handspikes.

APPENDIX II.†

SERVICE SUR LES CÔTES.

La flotte et l'armée de terre sont chargées de la défense mobile.

Les bâtiments à vapeur et les flotilles armés d'obusiers sont particulièrement propres à la défense des côtes.

Des corps de troupes réunis dans des centres d'action se tiennent prêts à se porter sur les points menacés, des batteries mobiles d'obusiers de 16ᶜ et 12ᶜ, suivant les localités, pretent leur appui à ces corps.

Un service rapide de signaux est établi, avec les ressources locales, entre les bâtiments, les vigies, les troupes mobiles et les batteries permanentes.

L'ordonnance du 3 Janvier, 1843, détermine: que dans les ports militaires, l'armée de mer sera chargée spécialement, sous les ordres du commandant des forces de terre,

* Vide Plates V. VI., where ring-bolts to correspond are shewn also on the ends of the platform as originally constructed.

† Extracts from 'Aide-Mémoire à l'usage des Officiers d'Artillerie,' 2nd ed. p. 402.

de l'armement, du service et de la garde de batteries qui ont une vue directe sur les ports, sur les rades intérieures adjacentes à ces ports, sur les passes et goulets conduisant aux rades intérieures, toutes les fois que les ouvrages auxquels appartiendront ces batteries, n'intéresseront pas principalement le système de la défense, du côté de terre, de la place et de ses dépendances.

Le personnel des batteries permanentes confiées au service de terre est fourni par l'artillerie, les autres troupes, les canonniers vétérans, la garde nationale, les brigades de douane, ou d'anciens canonniers pris dans la population des côtes, à raison de 5 hommes par pièce, dont un pointeur exercé.

Les ouvrages de la défense permanente sont divisés en 3 classes, suivant leur importance.

1re *Classe.*—Ouvrages destinés à la défense des ports militaires, des grands ports marchands et des points principaux des îles.

Cette fortification se compose de forts extérieurs capables de résister à des attaques régulières ou d'empêcher un bombardement, et d'une enceinte continue, suffisante contre une attaque de vive force.

2e *Classe.*—Ouvrages qui protègent les mouillages et les passes propres aux escadres de guerre. Ils consistent dans un système de forts ou de batteries se rattachant aux places.

3e *Classe.*—Ouvrages qui défendent les petits ports du commerce, les mouillages propres aux bâtiments marchands, les refuges de la navigation côtière. Ils se bornent à des batteries avec réduits.

Cette classification règle les approvisionnements des batteries ; elle ne détermine pas d'une manière absolue leur armement, qui est subordonné à des circonstances diverses, non plus que la force de leurs réduits, également variable.

L'armement des batteries est réglé d'après la force des bâtiments qu'elles peuvent avoir à combattre, laquelle dépend de la nature de la côte, et principalement de la profondeur de l'eau.—Le tirant d'eau des bâtiments de guerre est à peu près, savoir :

Vaisseaux de 74 à 120 canons,	7^m 5 à 9^m	
Frégates de 44 à 60 „	6	à 7
Bâtiments de 24	5	
„ 16	4	
„ 10	3	

Les canons de 30 * et obusiers de 22^c † de la marine sont employés à combattre les bâtiments en marche, jusqu'à la distance efficace de 2400 mètres. Les canons commencent le feu à boulet plein ; on continue à tirer les projectiles creux. Les mortiers de 32^c ‡ de la marine, dont la portée s'étend à 4000 mètres, sont réservés contre les mouillages. Il résulte de l'expérience, qu'une batterie de 4 pièces de gros calibres a l'avantage sur un vaisseau de 120 canons.

Les projectiles ricochent mieux sur l'eau que sur la terre et perdent peu de leur force ; ils peuvent, après avoir ricoché, traverser à 1200 mètres le flanc d'un vaisseau de haut bord. Les projectiles creux qui pénètrent dans les bordages au-dessous de la ligne de flottaison causent de larges voies d'eau par leur explosion. ('Epreuves de Brest, 1824.)

La hauteur à donner à la batterie au-dessus du niveau de la mer, est de 10 à 15 mètres. On doit se rapprocher autant que possible de ces limites, la 1re étant nécessaire pour mettre la batterie à l'abri des inondations dans les gros temps ; la 2e permettant le ricochet jusqu'à 200 mètres et suffisant pour éviter celui des vaisseaux, qui part de 5 à 6 mètres au plus au-dessus de l'eau.

La hauteur de la batterie se prend de la crête intérieure de son parapet. Elle se

* = 32 English. † = 8·661 inches English. ‡ = 12·6 inches English.

compose de son élévation au-dessus des plus hautes marées et de la quantité variable dont la mer se trouve au-dessous de ce niveau au moment du tir. Ces variations, qui sont inégales pour les différents points d'une même côte, et qui changent d'un jour à l'autre pour le même point, peuvent s'élever jusqu'à 12 mètres. Il importe de les bien connaître pour fixer la position de la batterie.

Tirer de plein fouet à la flottaison ; si le coup est un peu bas, le ricochet l'amène sur le bâtiment. Ne tirer dans les manœuvres qu'avec des fusils de rempart. On ne fait plus usage du tir à boulets rouges. Si l'on a affaire à plusieurs bâtiments, diriger toutes les pièces de la batterie sur celui qui se trouve le plus à portée.

Connaître exactement les distances de tous les points remarquables, et l'afficher dans le magasin au matériel et dans le corps de garde, afin de pouvoir évaluer celles des bâtiments.

Pointer une bouche à feu de but-en-blanc sur la ligne de flottaison et la faire tourner ainsi pointée sur sa plate-forme horizontale, pour rapporter la direction du rayon visuel à des objets de la côte dont les distances sont connues ; avoir égard dans cette opération à la hauteur actuelle de la mer.

Observer les ricochets sur l'eau.

Tirer à balles sur les débarquements.

Tenir en barils ou caisses, derrière l'abri de la batterie, 4 charges par bouche à feu, quelques projectiles empilés à gauche et en arrière de leurs bouches à feu, les bombes et obus l'œil en bas ; les boute-feu allumés en nombre suffisant.

Se garder avec soin contre les surprises, surtout la nuit ; observer tout ce qui se montre en mer ou sur la côte ; être attentif à tous les signaux.

Veiller à la conservation du matériel avec tous les soins convenables ; aérer les magasins dans les temps secs ; faire mouvoir tous les jours les châssis d'affût.

Les obusiers de campagne ou de montagne sont destinés à agir contre les débarquements ; les enterrer à demi, s'il est possible, près du rivage, donnant un feu rasant et prenant les chaloupes en flanc. Ils tirent à obus contre les embarcations, à balles contre les troupes débarquées.

Nombre d'hommes nécessaires au service des diverses bouches à feu.

Canons de siége	7	hommes.	Mortiers de 22^c et 15^c . .	3	hommes.
Obusiers de siége . . .	5	„	Pierriers	5	„
Can. sur affût de pl. et côte	5	„	Bouches à feu de campagne	8	„
Mortiers de 32^c et 27^c . .	5	„	Obusiers de montagne . .	6	„

In addition to the above, and to the suggestions in the text as to the heights of batteries above the sea level, the following, from the same work, is given as laying down an important principle.

"Nous croyons qu'il convient d'établir des principes qui ne sont pas encore assez connus, sur l'emplacement des batteries de côte. Les boulets ricochent sur l'eau mieux que sur terre, et tous les ricochets, sous 2 ou 3 degrés, font perdre peu de force aux gros boulets. Ceux de 24, sous 4 degrés, conservent encore plus de force qu'il ne faut pour perçer le flanc d'un vaisseau, tel fort qu'il soit, à 300 toises et plus ; ainsi toute batterie qui, par son peu d'élévation, sera exposée à l'égoût des ricochets d'un vaisseau, recevra tous ses coups traînans qui lui feront encore beaucoup de mal ; et toute batterie qui sera assez élevée pour tirer à bonne portée sur un vaisseau, sous l'angle de 4 à 5 degrés, lui fera tout de mal possible, puisque les boulets traînans de la batterie iront tous au vaisseau ; mais ceux partant du vaisseau, qui est plus bas que la batterie, ne pourront ricocher assez haut pour monter jusqu'à elle, si elle a la hauteur supposée ci-dessous."

TABLE I.

Proportion of Ammunition and Stores at 100 Rounds per Piece, for the Armament of Coast Defences under ordinary circumstances.

Stores, &c.	8-inch gun.	56-pounder.	32-pounder.	24-pounder.	18-pounder.	12-pounder.	10-inch howitz.	8-inch howitz.	$5\frac{1}{2}$-inch howitz.	13-inch mortar.	10-inch mortar.	8-inch mortar.
Handspikes { common	6	6	6	6	4	4	4	4	4	4	4	4
Handspikes { roller; two for each piece on traversing platforms.												
Handcrow levers, 6 feet; a small proportion in a battery										2	2	2
Iron crows, $5\frac{1}{2}$ feet; ditto										2	2	2
Sponges,* with staves, &c., complete .	2	2	2	2	2	2	2	2	2	2	2	2
Staves, sponge, spare	1	1	1	1	1	1	1	1	1	1	1	1
Wadhooks with staves	1	1	1	1	1	1	..	..	..	..	..	..
Ladles, copper, with staves	1	1	1	1	1	1	..	..	..	..	..	..
Cartouches, leather, large	1	1	1	1	1	1	1	1	1	1	1	1
Clippers, portfire	1	1	1	1	1	1	1	1	1	1	1	1
Flints, musket †	10	10	10	10	10	10	10	10	10	..	..	..
Hammers, claw, small	1	1	1	1	1	1	1	1	1	1	1	1
Heads, spare { rammer	1	1	1	1	1	1	1	1	1	1	1	1
Heads, spare { sponge	1	1	1	1	1	1	1	1	1	1	1	1
Horns, powder	1	1	1	1	1	1	1	1	1	1	1	1
Irons, priming, long, sets	1	1	1	1	1	1	1	1	1	1	1	1
Vent, bits	1	1	1	1	1	1	1	1	1	1	1	1
Linstocks with cocks	1	1	1	1	1	1	1	1	1	1	1	1
Hammers, detonating, with laniards .	1	1	1	1	1	1	1	1	1	..	..	..
Hambro' line, skeins	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	..	..	..
Pins, linch, iron, spare	1	1	1	1	1	1	1	1	1	..	..	..
Punches for vents	1	1	1	1	1	1	1	1	1	1	1	1
Spikes, common	2	2	2	2	2	2	2	2	2	2	2	2
Tampeons	..	..	..	..	..	..	..	..	..	1	1	1
Thread, pack in lbs.	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Wads, junk	100	100	100	100	100	100	..	..	..	..	..	..
Ammunition and Laboratory Stores.												
Shot, round, hollow	80	..	..	..	..	..	..	..	..	..	..	..
Shot { round	..	100	80	80	80	80	..	..	..	..	..	..
Shot { case { common	5	..	5	5	5	5	10	10	10	..	..	..
Shot { case { spherical	..	..	5	5	5	5	..	20	20	..	..	..
Shot { grape	..	..	10	10	10	10	..	..	..	..	..	..
Shot { pound, rounds; for mortars, according to circumstances.												
Wooden bottoms for pound shot; ditto												
Shells, common, empty	15	..	..	..	..	..	90	70	70	95	95	100
Carcasses, round, fixed	..	..	..	..	..	..	..	..	..	5	5	..
Cartridges for { charge, flannel or paper, with flannel bottoms	100	100	100	100	100	100	100	100	100	..	..	..
Cartridges for { bursters, flannel { common . .	15	..	..	..	..	..	90	70	70	..	..	..
Cartridges for { bursters, flannel { spherical . .	..	..	5	5	5	5	..	20	20	..	..	..
Valenciennes composition, proportions; according to circumstances.												
Gunpowder { large grain, whole barrels 90 lbs. each	$11\frac{1}{2}$	$17\frac{3}{4}$	11	9	$6\frac{3}{4}$	$4\frac{1}{2}$	$10\frac{1}{2}$	6	$2\frac{3}{4}$	17	$7\frac{1}{4}$	$4\frac{1}{4}$
Gunpowder { fine grain, lbs	1	1	1	1	1	1	..	..	..	..	..	..
Gunpowder { mealed, lbs.	..	..	..	..	..	..	1	1	1	1	1	1

* Add now, the like number of rammers with staves.

† Only if flint locks are used.

TABLE I.—*Continued.*

Stores, &c.	8-inch gun.	56-pounder.	32-pounder.	24-pounder.	18-pounder.	12-pounder.	10-inch howitz.	8-inch howitz.	5½-inch howitz.	13-inch mortar.	10-inch mortar.	8-inch mortar.
Fuzes for common shells	17	..	..	..	..	..	100	77	77	105	105	110
Fuzes for spherical case shot, cut, L '3	..	..	5	5	5	5	..	20	20	..	..	..
Fuzes for spherical case shot, cut, D '4	..	..	5	5	5	5	..	20	20	..	..	..
Fuzes for spherical case shot, cut, E '5	..	..	5	5	5	5	..	20	20	..	..	..
Fuzes for spherical case shot, uncut	..	..	5	5	5	5	..	20	20	..	..	..
Portfires	6	6	6	6	6	6	6	6	6	6	6	6
Tubes, brass, fixed *	60	60	60	60	60	60	60	60	60	60	60	60
Match, slow, yards	4	4	4	4	4	4	4	4	4	4	4	4
Match, quick, lengths	30	..	10	10	10	10	180	180	180	190	190	200
Augers, fuze	..	..	1	1	1	1	..	1	1	..	..	..
Barrels, budge	..	..	..	..	..	..	..	..	..	1	1	1
Boxes, tin, with straps for fuzes, black	..	..	1	1	1	1	..	1	1	..	..	..
Boxes, tin, with straps for fuzes, blue	..	..	1	1	1	1	..	1	1	..	..	..
Bags, canvass, with straps for fuzes, striped	..	..	1	1	1	1	..	1	1	..	..	..
Bags, canvass, with straps for fuzes, yellow	..	..	1	1	1	1	..	1	1	..	..	..
Boxes, tube (in pockets, leather)	1	1	1	1	1	1	1	1	1	1	1	1
Compasses, pairs	..	..	..	..	..	..	1	1	1	1	1	1
Engines for drawing fuzes	..	..	..	..	..	..	1	..	..	1	1	..
Files, 3-square	1	1	1	1	1	1	1	1	1	1	1	1
Funnels, shell	1	1	1	1	1	1	1	1	1	1	1	1
Funnels, for loading mortars	..	..	..	..	..	..	..	..	..	1	1	1
Hooks, shell, hand, pairs	..	..	..	..	..	..	2	..	..	2	2	..
Hooks, shell, beam	..	..	..	..	..	..	2	..	..	2	2	..
Knives, cutting	1	1	1	1	1	1	1	1	1	1	1	1
Mallets and setters	1, 2	..	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2	1, 2
Measures, copper, for powder, 4 lbs. to 1 oz., sets	1	1	1	1	1	1	1	1	1	..	..	..
Needles, laboratory	2	2	2	2	2	2	2	2	2	..	..	..
Perpendiculars	..	..	..	..	..	..	1	1	1	1	1	1
Pincers, fuze, iron, pairs	1	1	1	1	1	1	1	1	1	1	1	1
Plummets, lead	..	..	..	..	..	..	..	..	..	1	1	1
Quadrants, brass	..	..	..	..	..	..	1	1	1	1	1	1
Diagonal scales	..	..	..	..	..	..	1	1	1	1	1	1
Saws, tenon	1	1	1	1	1	1	1	1	1	1	1	1
Scissors, pairs	1	1	1	1	1	1	1	1	1	1	1	1
Scales, copper, with beams, pairs	..	..	..	..	..	..	..	..	..	1	1	1
Scrapers for shells	..	..	..	..	..	..	1	1	1	1	1	1
Screws for drawing corks	1	1	1	1	1	1	1	1	1	1	1	1
Sticks, portfire	2	2	2	2	2	2	2	2	2	2	2	2
Sheep skins	..	..	..	..	..	..	..	..	..	1	1	1
†Thumbstalls	2	2	2	2	2	2	2	2	2	2	2	2
Tongs for placing shells ‡	..	..	..	..	..	..	1	1	..	..	..	..
Weights, brass, 4 lb. piles	..	..	..	..	..	..	..	..	..	1	1	1
Worsted, oz.	1	1	1	1	1	1	1	1	1	..	..	..

* Add 120 detonating tubes for each gun or howitzer, } as recently ordered.
† Tangent scales, wood, 1 for each gun or howitzer, }

‡ Bearers, &c., for carrying hot shot, are considered as belonging to the Furnace Equipment.

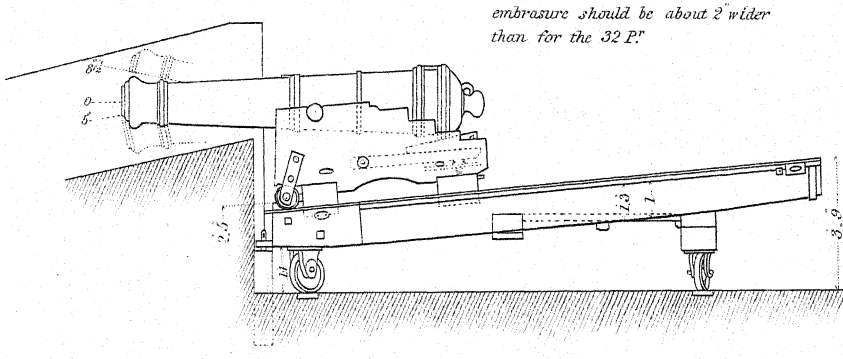
DWARF WOODEN TRAVERSING PLATFORM,

OF L^T COLONEL EMMETT, R.N.

M.G. & B.O. 1 April 1846. superseding that of 6 May 1844. & 15 Dec^r 1845 Applicable from 8 inch Gun of 65^cwt to 18 P^r inclusive.

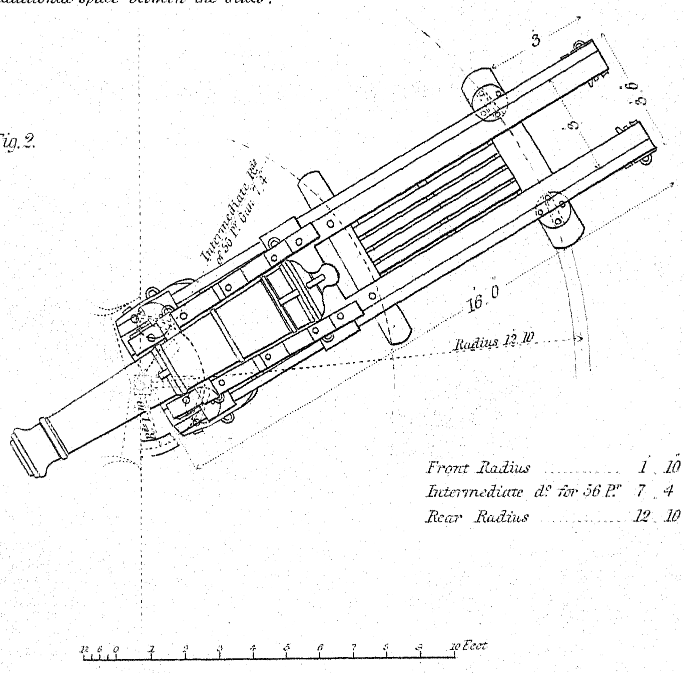
The Platform for the 56 P^r is 4 feet wide; for this Gun the neck of the embrasure should be about 2" wider than for the 32 P^r

Fig. 1.



The Slides of S.S. heavy Pivot Guns are in width between the sides the same as the Dwarf Platform for Guns to 65^cwt inclusive; and Land, or S.S. Carriages may be worked on either. For Guns above 65^cwt the Dwarf Platform is 5 inches wider; but S.S. Carriages may be worked upon it by lining up the front and hind blocks to the additional space between the sides.

Fig. 2.



Front Radius	1	10
Intermediate d^o for 56 P^r	7	4
Rear Radius	12	10

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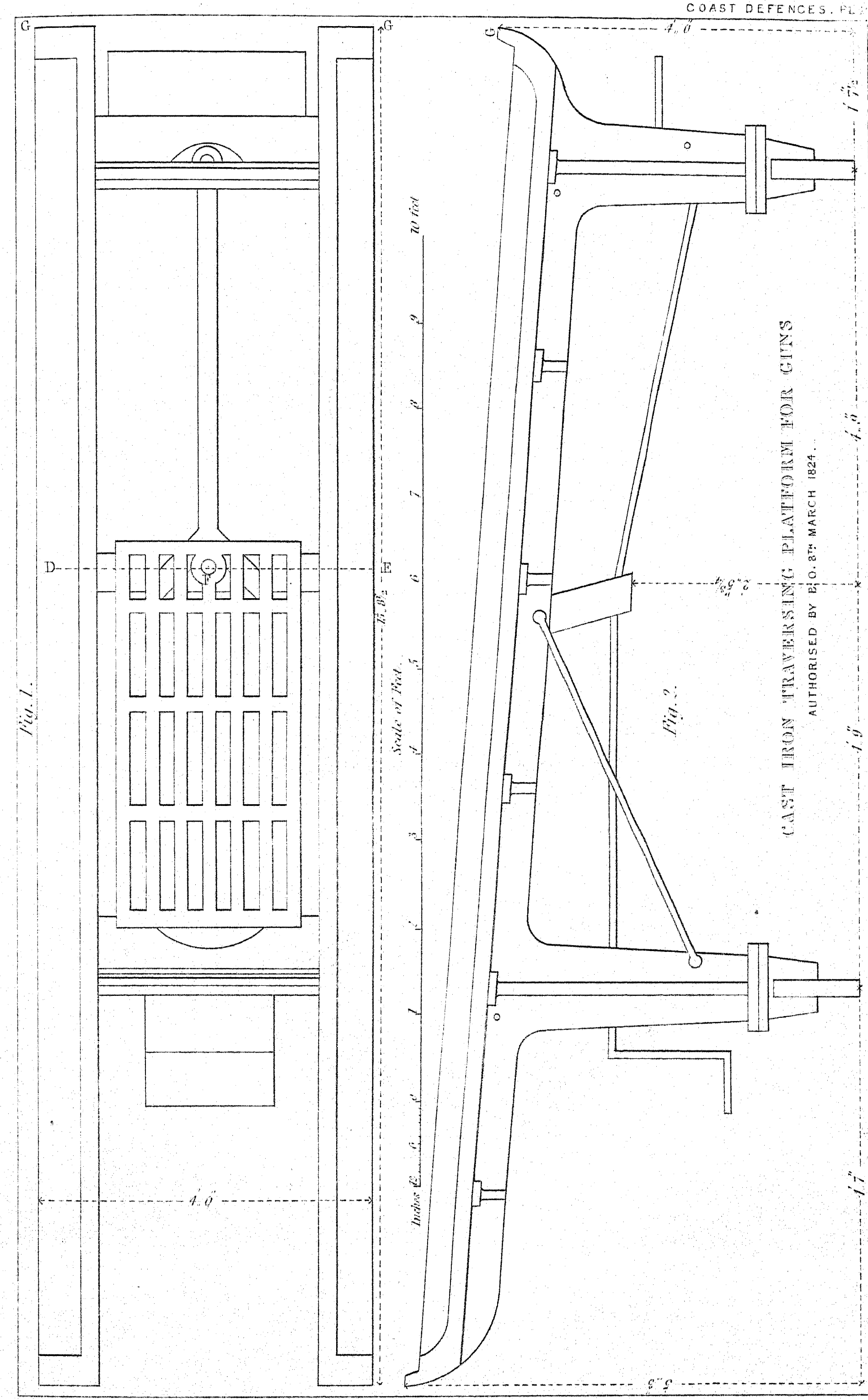


CAST IRON TRAVERSING PLATFORM FOR GUNS

AUTHORISED BY B. O. 8TH MARCH 1824.

Defe

DIAGRAM OF THE CENTRAL LINES OF THE IRON RACERS,

WHEN IN FRONT__CENTRE__OR REAR

Fig. 5.

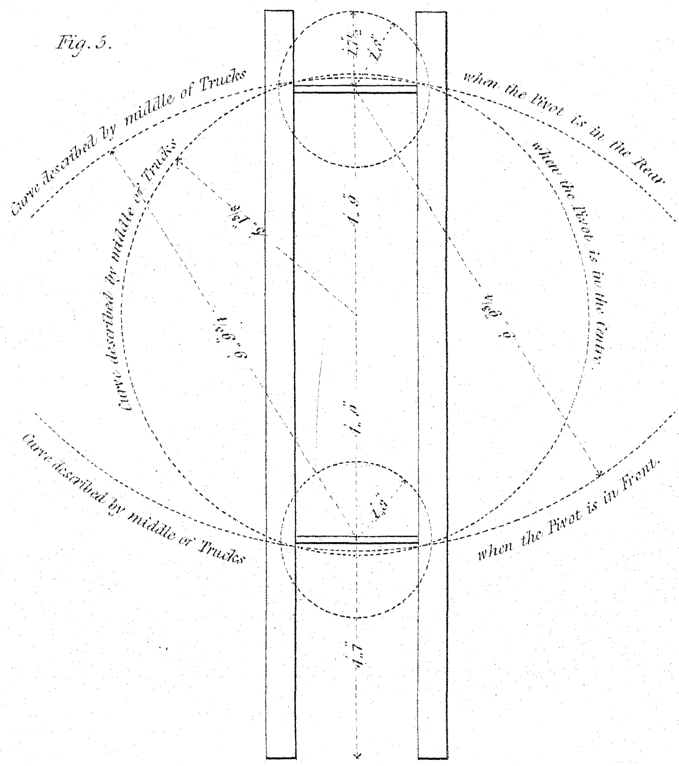


Fig. 3.
Front Elevation

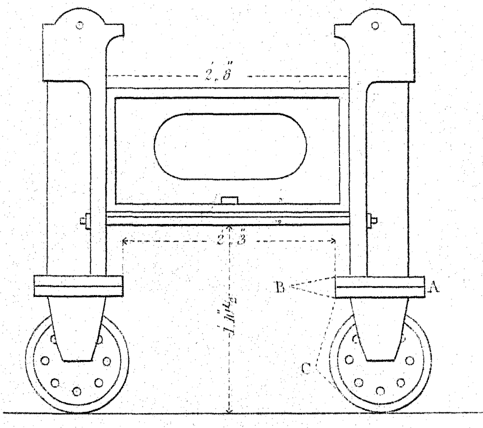
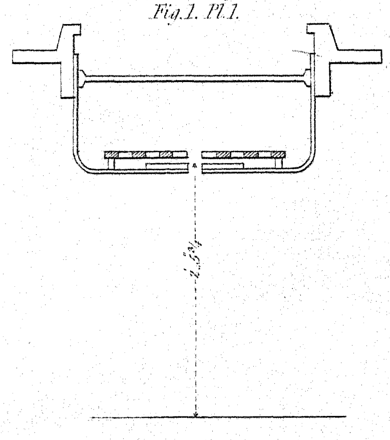
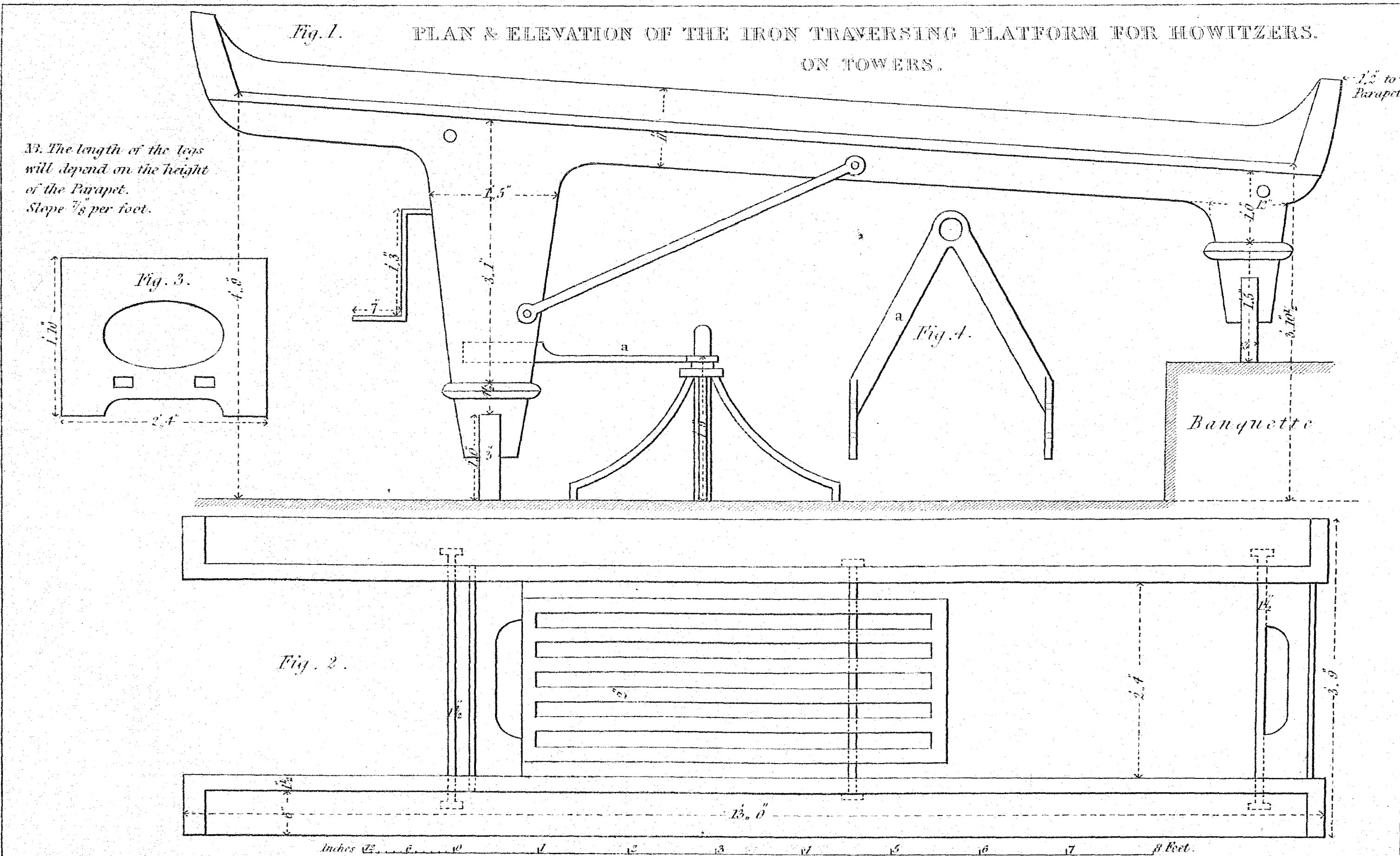


Fig. 4.
Section through C D
Fig. 1. Pl. 1.



Defe

PLAN & ELEVATION OF THE IRON TRAVERSING PLATFORM FOR HOWITZERS. ON TOWERS.

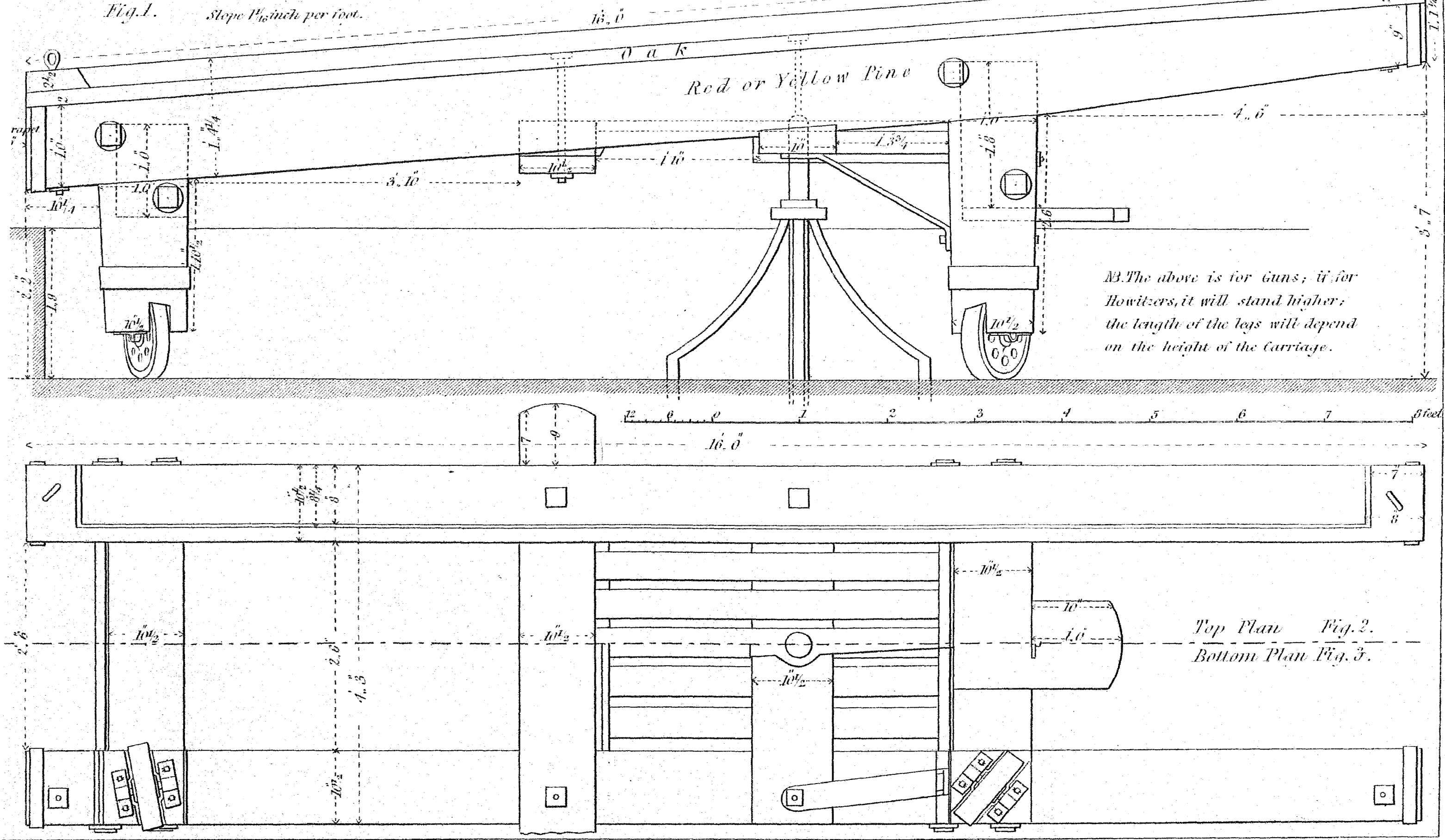


J. W. Lowry fc.

Defe

PLATFORM FURNISHED TO THE CIRCULAR TOWERS IN ENGLAND

AS ADAPTED TO A 6 FT PARAPET IN A 20 FT DIAMETER TOWER



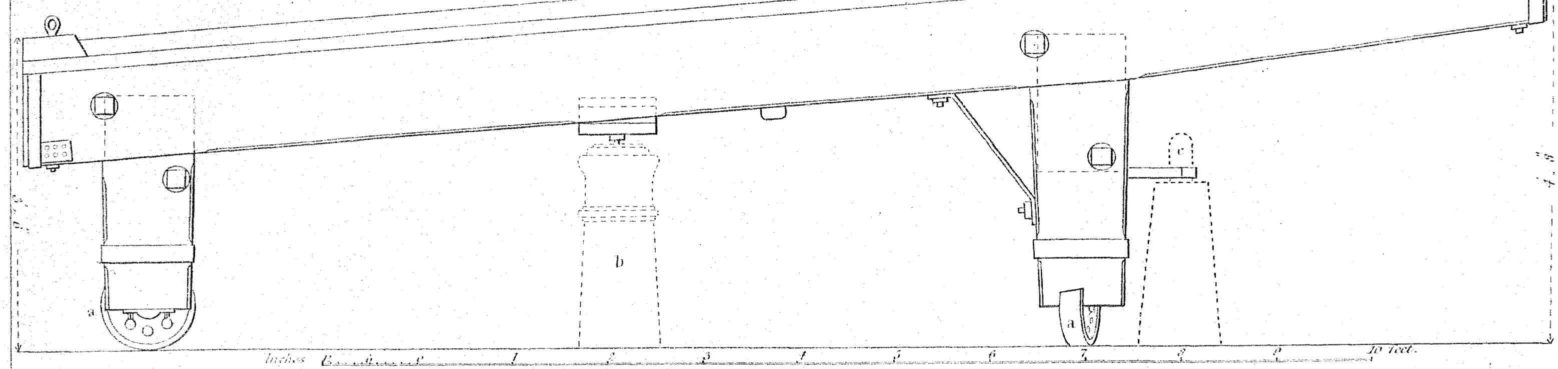
Defe

WOODEN TRAVERSING PLATFORM FOR GUNS OR HOWITZERS IN BATTERIES.

Slope $\frac{7}{8}$" per foot.

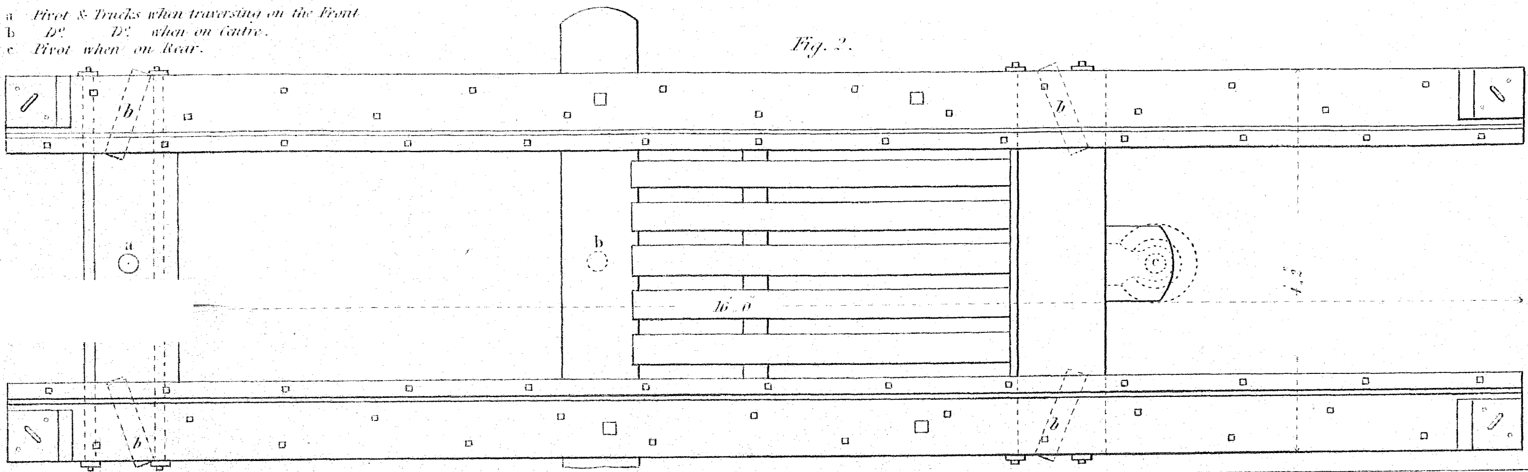
NB. The length of the legs will vary with the height of the Parapet.

Fig. 1.



a Pivot & Trucks when traversing on the Front
b D° D° when on Centre.
c Pivot when on Rear.

Fig. 2.



J.W. Lowry

TABLE II.

Shewing the principal Heights of the Guns of Shipping above the water.

Rate.	Class.	Height of quarter-deck above the sea.		Height of gun-deck above the sea when it carries guns.		Height of main-top above the sea.		Remarks.
		ft.	in.	ft.	in.	ft.	in.	
1st	120	26	0	4	0	89	0	Main-top large enough to carry a carronade.
"	104	25	6	3	10	87	6	
2nd	90	19	6	5	0	86	0	
"	84	19	6	5	0	86	0	
"	80	19	9	5	0	86	3	
3rd	74	18	10	4	0	78	6	
Razee	50	14	0	7	0	77	6	
"	"	15	6	8	0	80	0	
Frigates, Corvettes, and Brigs.	36	13	6	6	6	71	0	
	44	11	8	5	0	69	0	
	26	12	3	5	6	64	6	
	28	11	6	3	3	52	6	
	18	—		6	0	52	0	
	"	—		6	0	52	0	
	16	—		5	0	52	6	
	"	—		5	3	51	6	
	10	—		5	9	48	6	
Steamer		—		11	9	79	0	
"		—		11	3	72	6	
"		—		9	6	60	6	
"		—		6	2	42	8	

Column 4.—The great variation in heights, as given in this column, arises from the difference between the old and new principles of construction, in which last it is a main point to keep the guns as high out of water as possible.

Column 5.—Given in consequence of the effect produced at Algiers in enfilading (at close quarters) a thitherto troublesome battery by hoisting a carronade into the main-top of a line-of-battle ship that from its position was thus enabled to rake the work most effectually.

DEFILADE.

In Plan—the direction given to the faces of a work, or to the lines of an approach, to avoid enfilade.

In Section—and with reference to Permanent Fortification, it implies the arrangements for preventing unnecessary exposure of the exterior and interior of works: to carry out both in conjunction is frequently an anomalous task.—*Vide* 'Command,' p. 226; and vol. ii., to which this part of 'Defilade' properly belongs.

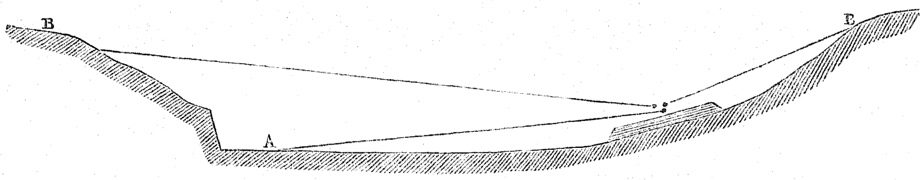
In Section—and with regard to Field Fortification, where exposure of the escarp is in general of little consequence, the task is comparatively simple *as far as it is practicable;* for, with the utmost skill, it will at times become a problem admitting only of a partial solution.

To defilade a Field-work, then, is merely so to arrange the heights of the different parts, that the enemy may not be able to see into it; and this is more appropriately and expeditiously effected by the eye and a few poles and profiles, than by resorting to theoretical and scientific proceedings,—though these last are generally indispensable in considerations of Permanent Fortification.

Defilade in plan requires no comments: as to that in section, works should be defiladed against musketry within 400 yards; and against artillery, within 1200 yards; for although this may be considered random practice, it will nevertheless keep the garrison in a state of constant disquietude.

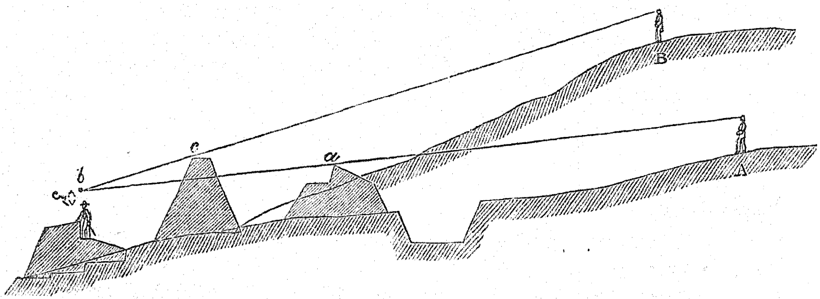
A work may require defilade either from a plain (A, fig. 1) below it; or from a height or heights (B) above it; or from a height or heights (A, fig. 6) adjacent.

Fig. 1.



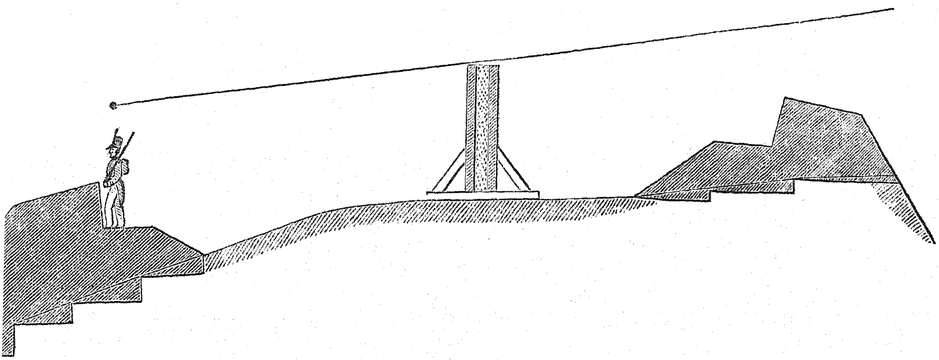
With regard to fig. 1, and exposure from A or B, in either case the nearest parapet to the enemy (*a*, fig. 2) must be, as far as possible, able to screen the space to be concealed, so that the line of fire (A *a*) may not go less than about 3 feet over the head of the man (*b*) on the opposite side of the work. If this cannot be done from a

Fig. 2.



too great command, as from B, a parados (*c*) becomes necessary,—still affording an equal cover to *b*, though leaving much of the space (*a c*) unprotected. In case of defilade from musketry only (fig. 3), the parados may be of two rows of plank and earth between, or of timber only: the scantling may in some degree depend upon the height, but more on the nature of the wood and the distance from the enemy.—*Vide* 'Barricade,' p. 126, and 'Penetration.'

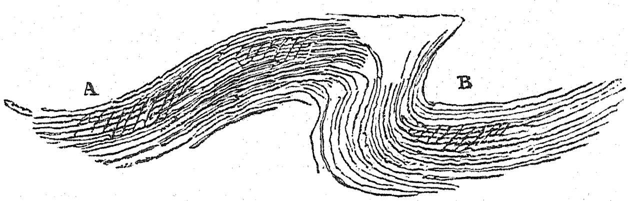
Fig. 3.

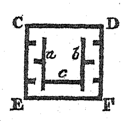


When the other lines of the work are liable to enfilade, either from the plain below or the heights above or adjacent, the best application of traverses must be made that circumstances will permit.*

Thus far relates to the simplest case—that of defilade against a single height; and with the simplicity, it often happens that the complete practicability disappears. The problem becomes more or less impossible, when it has reference to more heights (A, B, fig. 4) than one, more or less surrounding a work as well as commanding it.

Fig. 4.



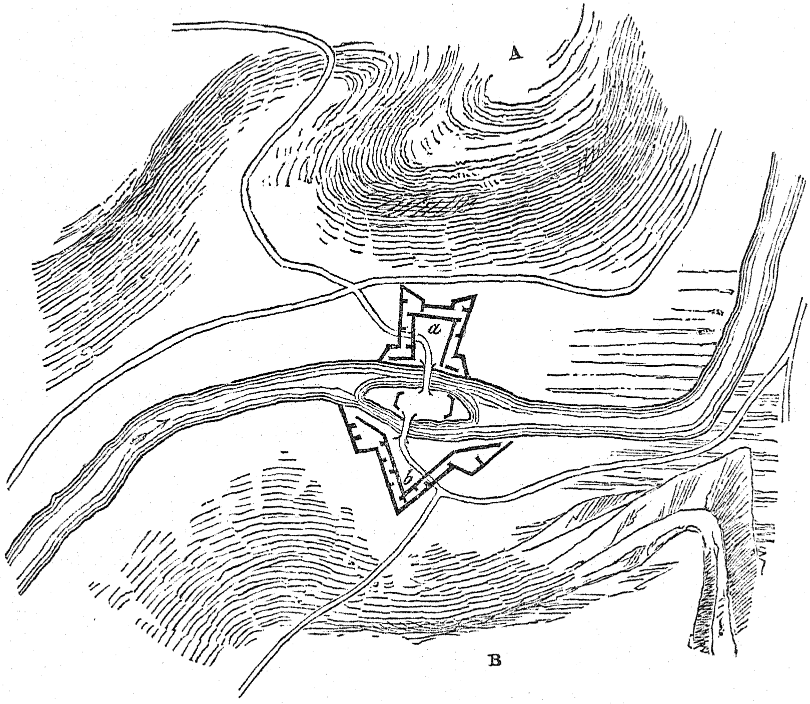


Thus, to prevent EF, CE, DF, from being taken in reverse from AB, the parados (*a*, *b*, *c*) are as indispensable as the traverses along CE, DF, to give some protection from enfilade.† And in fig. 5, where an old bridge has to be secured at all risks, at the

* Several of these figures are somewhat cariacatured, from want of space to give them in true proportion.

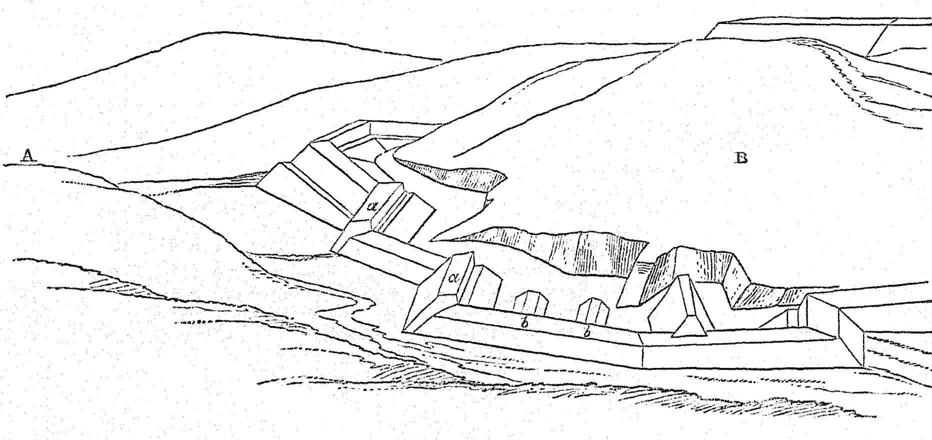
† Placed as CDEF is with regard to A and B, one side is taken in reverse, and two are enfiladed; but it would be still worse to turn the salients towards the hills, for then two sides would be seen in reverse, and the rest enfiladed. Hence, in such cases, a face should be presented to the enemy rather than an angle. If the work be an oblong, a long side should be turned towards A and B rather than a short one, as the defilade becomes easier thereby. With regard however to such a case as fig. 5, it matters little whether the work presents the front *a* to A, or the salient *b* to B. What would be an advantage under other circumstances in having such a front as *a*, is here rendered almost nominal by the direct fire from A, and that in reverse from B.

Fig. 5.



mouth of a valley, of which the two sides (A, B) cannot be kept free from the enemy, —it seems that nothing remains to be done but to double the works by the two conformable parados (a, b), in addition to such traverses as may be necessary. It is true that neither of these positions are of common occurrence, and would be very objectionable were it practicable to avoid them; but such instances are within the limits of possibility, and illustrate the case where complete defilade is out of the

Fig. 6.



question, and where works become so encumbered* with traverses and parados to effect it, as to lose much of their efficiency. Also, with reference to fig. 6, (in which it is also to be supposed that so very objectionable a tracing has been unavoidable,) defilade becomes of little use to the parts above, or on a level with A; and of still less to those below it, although every thing possible should be done,—such as raising the shorter faces (a, a), adding traverses (b, b), &c. The works and the ground immediately in rear of aa, bb, are barely screened; and the interior space (B) remains generally exposed.

"When works are placed within range of heights by which they are commanded, the choice of outline should be principally attended to; for among the different tracings which may be used, some will be much more easily defiladed than others.

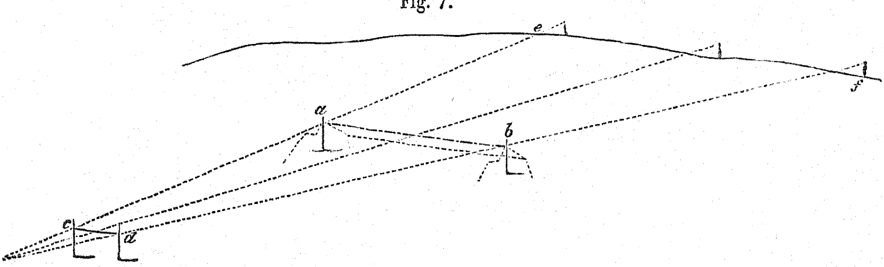
"The choice of a position to be fortified, as well as the particular method of occupying it by continued lines, or by lines with intervals, is therefore a matter of very great importance. If any of the heights commanding a position cannot be occupied, epaulements may then be thrown up, 50 or 60 yards in rear of the lines, to cover the troops intended for their defence.

"It is in general not possible to place all the crests of continued lines in the same plane of deflement; they should then be divided into parts, separated by traverses, each part having reference to its own planes of site and deflement."†

In laying out such a work as shewn in fig. 2, either the height of the crest a, or that of $b+3$ feet, must be assumed to commence with, and as the regulating dimension. If the hill (A) be accessible, then by holding up a pole at b, with a short cross-piece marking the intended height of $b+3$ feet, the line drawn from that point to the height of the eye at A, intersecting a pole at a, shews the height of the crest that will cover the man at b. In like manner, the height of the parados (c) can be determined from B. If, however, the point A (or B) be not accessible, then the height of $b+3$ feet being marked on the staff, the eye must be raised to look over the cross-piece to see where the height of a man at A (or B) cuts on the pole (a), to give the height of the crest of the parapet.

And in the same way that any one point is obtained, any number of the like completing the required form may be determined: and, if raising at one spot exposes the work too much at another, a judicious compromise, so making the best of the matter, is frequently all that can be effected when more than a single hill is to be considered.

Fig. 7.



* Although a parados takes up so much room, yet it may be turned to good account in the formation of blindages.

† From Macaulay's 'Field Fortification.'

It will generally happen when the ground opposite is simple, that a length of line ($a\,b$, fig. 7) may be defiladed at once by looking along a string ($c\,d$) parallel to the crest of the hill (ef) from a central or other suitable point (g), which (as at b, fig. 3) must include the extra 3 feet of height.* When the whole work has been thus marked out in elevation by a skeleton of poles and cords, and the defilade has been decided to be as satisfactory as circumstances permit, the profiles may be set up, dressing on the "skeleton of poles and cords," and the work completed according to the usual routine of execution.

The defilade for musketry will do for that of artillery, provided the parapets, parados, and traverses are thick enough.

Fig. 8.

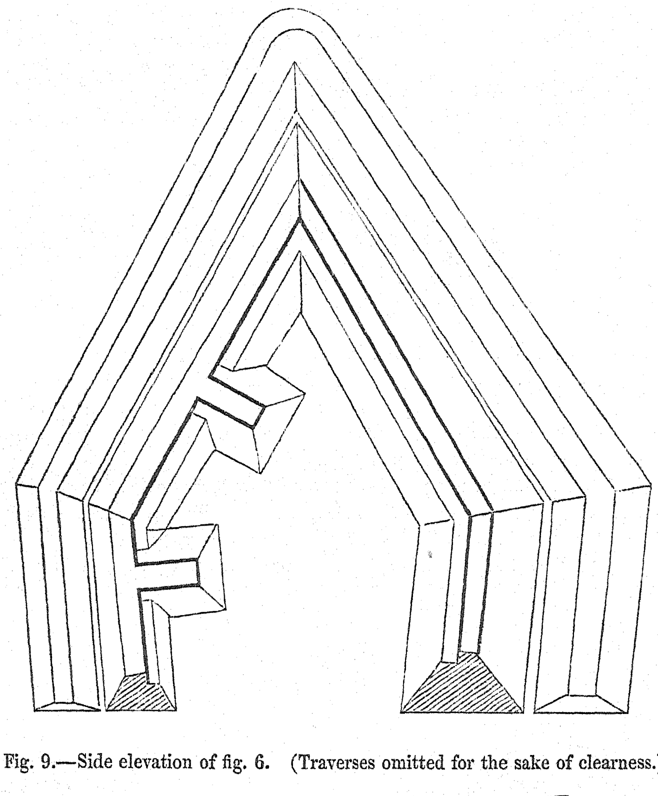
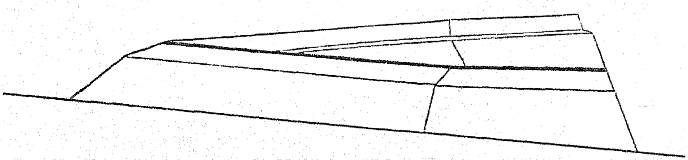


Fig. 9.—Side elevation of fig. 6. (Traverses omitted for the sake of clearness.)



* Some prefer considering the 3 feet as added to e or f, instead of being thus allowed for at g.

If fig. 8 or 10 be a lunette on ground sloping up towards a neighbouring hill in front, with the left face and flank liable to enfilade and reverse from the summit, it will be decided by local circumstances whether the required protection is to be obtained by general defilade of the whole work, and by traverses, as in figs. 8, 9, or by a parados, as in figs. 10, 11, raised sufficiently at *a* to intercept the enfilade,

Fig. 10.

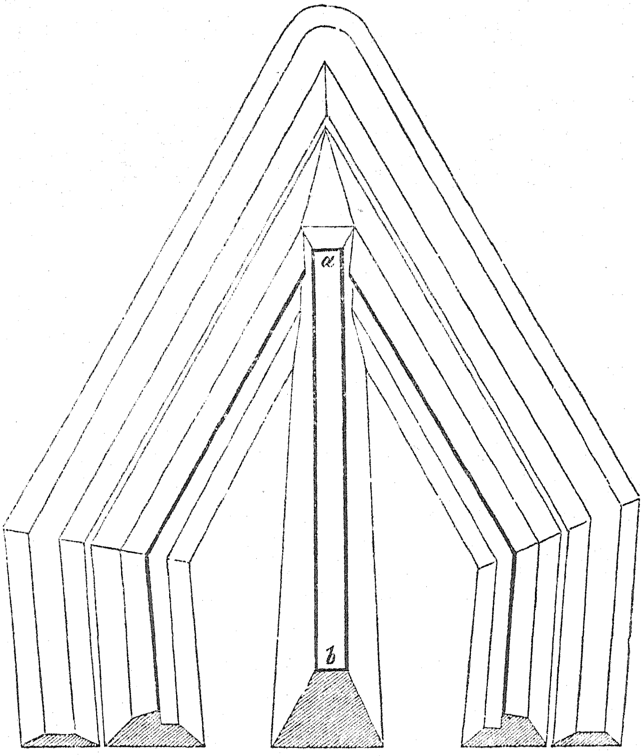
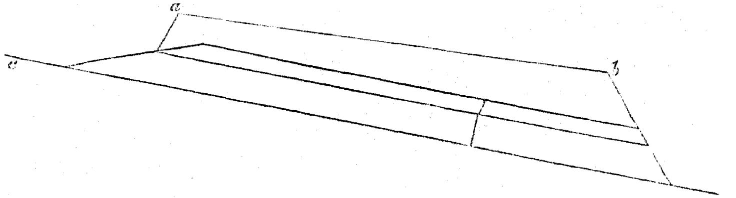


Fig. 11.—Side elevation of fig. 8.



and at *b* to screen the left face and flank from reverse fire, leaving the crest of the parapet parallel to the plane of site (*c d*). If both planes be equally effective, it then remains only a question of time, labour, and material.

Defilade by sinking the interior of a work is on many accounts objectionable.

It will generally happen when the ground opposite is simple, that a length of line (*a b*, fig. 7) may be defiladed at once by looking along a string (*c d*) parallel to the crest of the hill (*ef*) from a central or other suitable point (*g*), which (as at *b*, fig. 3) must include the extra 3 feet of height.* When the whole work has been thus marked out in elevation by a skeleton of poles and cords, and the defilade has been decided to be as satisfactory as circumstances permit, the profiles may be set up, dressing on the "skeleton of poles and cords," and the work completed according to the usual routine of execution.

The defilade for musketry will do for that of artillery, provided the parapets, parados, and traverses are thick enough.

Fig. 8.

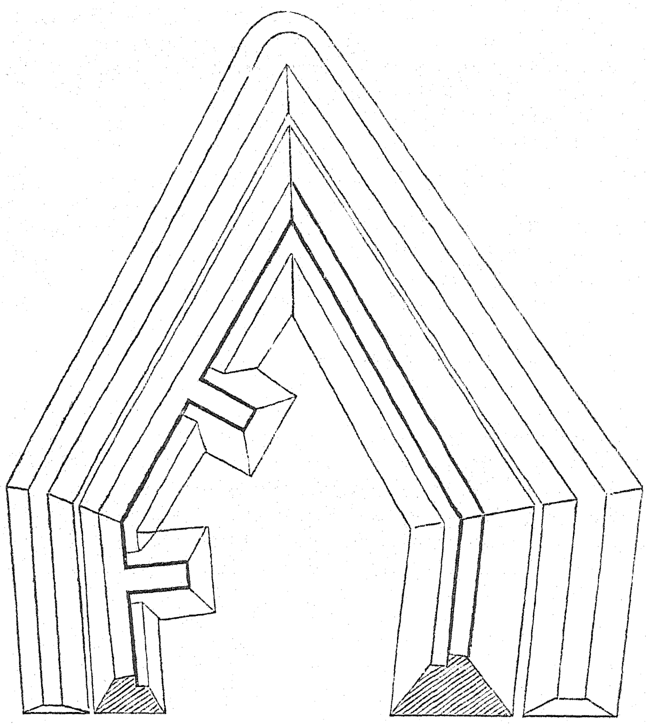
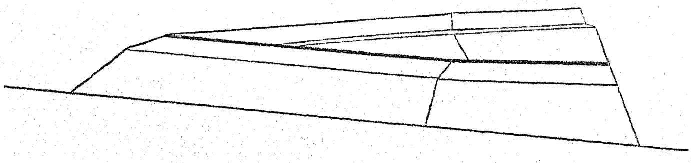


Fig. 9.—Side elevation of fig. 6. (Traverses omitted for the sake of clearness.)



* Some prefer considering the 3 feet as added to *e* or *f*, instead of being thus allowed for at *g*.

If fig. 8 or 10 be a lunette on ground sloping up towards a neighbouring hill in front, with the left face and flank liable to enfilade and reverse from the summit, it will be decided by local circumstances whether the required protection is to be obtained by general defilade of the whole work, and by traverses, as in figs. 8, 9, or by a parados, as in figs. 10, 11, raised sufficiently at *a* to intercept the enfilade,

Fig. 10.

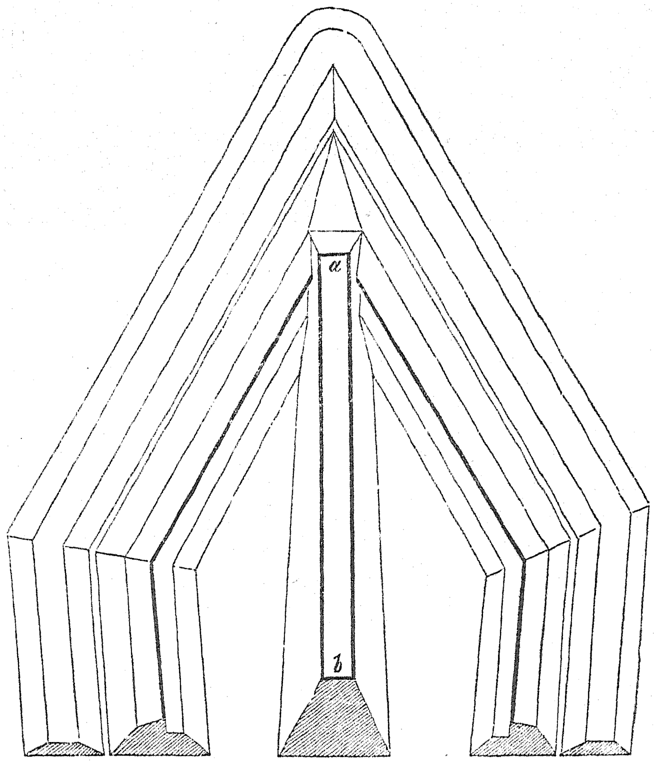
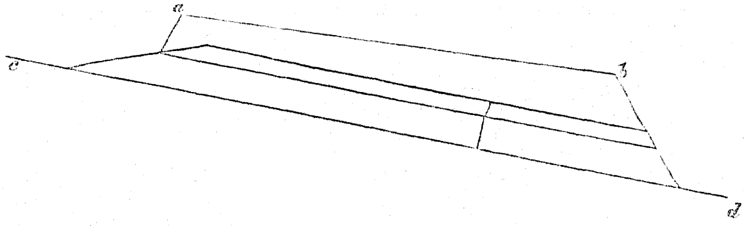


Fig. 11.—Side elevation of fig. 8.

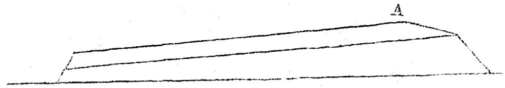


and at *b* to screen the left face and flank from reverse fire, leaving the crest of the parapet parallel to the plane of site (*c d*). If both planes be equally effective, it then remains only a question of time, labour, and material.

Defilade by sinking the interior of a work is on many accounts objectionable.

When the hill in front has no great extent towards the flanks, the interior of a work may be protected by merely elevating the parapet from the rear towards the salient (A, fig. 12).

Fig. 12.



It may be admissible to anticipate two important points in 'Tracing,' in order to simplify the execution of 'Defilade.'

Much time, labour, and profiling stuff will often be saved if the profiles be set up at once on the capitals of the angles, instead of allowing two for each face along its

Fig. 13.

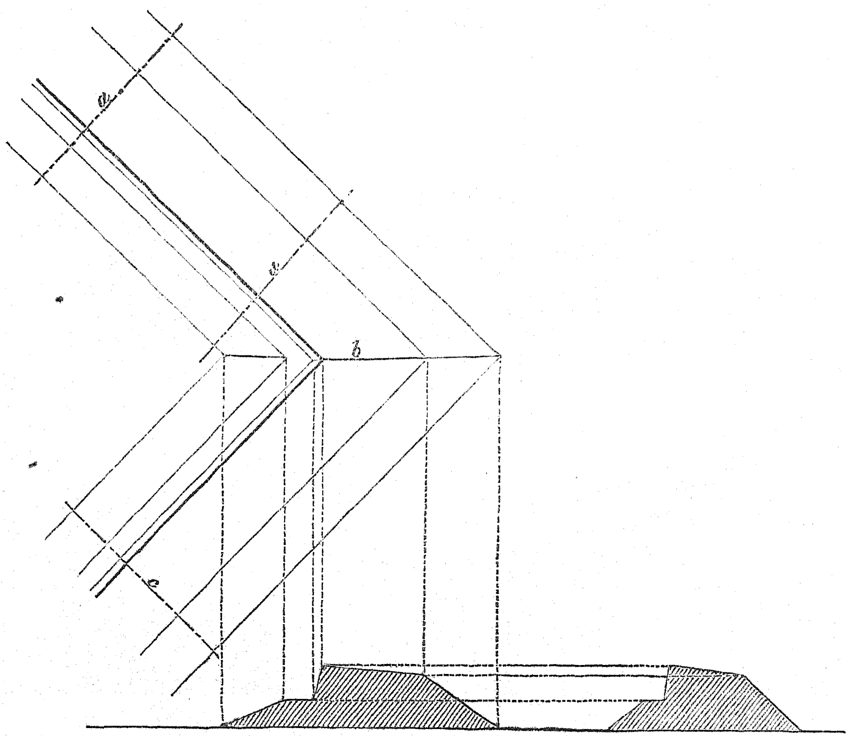


Fig. 14.—Profile *b*. Fig. 15.—Profile *a*.

length. It will require a slight orthographic projection, which, with a little care, a carpenter's rule, and a pencil, can generally be made on the spot. Thus, if *b* (fig. 13) be substituted for *a, a* or *a, c*, the section will be fig. 14 instead of fig. 15.

Further, much perplexity will also be saved by remembering that the spirit of the tracing lies in the position of the interior crest of the parapet: if this be mainly attended to, the remaining lines, especially the foot of the exterior slope, will *find out their own places* according as the surface of the ground is level or otherwise: unless that surface be a perfect plane, and the crest of the parapet is parallel to it, the only lines that necessarily remain parallel amongst themselves are three; viz., the said interior crest of the parapet, the foot of its interior slope, and the outer edge of the terreplein of the banquette. R. J. N.

DEMOLITION OF WORKS AND BUILDINGS.*

Under this subject we shall confine our observations to the following:—

Demolition of Revetments,
Towers,
Magazines,
Military Buildings,
Cisterns,
Bridges,
Barriers,
Booms.

REVETMENTS.

As no certain rules have been arrived at for determining the proper charges for throwing down masonry, we shall offer a few examples where the results have been successful, leaving the Engineer who may be called upon this service to use his judgment, there being a variety of points for consideration before he can determine the quantity of powder necessary to be used.

1st. The section of the wall should be ascertained.

2nd. The nature and quality of the revetment, whether brick or stone; the description of stone, as the weight will be different according to the materials with which the wall is built, as whether rubble, tapia, or ashlar. Climate has a great effect upon masonry: in hot climates, masonry may be considered invariably to be of a much better quality than in cold regions, the mortar being harder, and the work more closely united. It will be necessary to ascertain whether there are counterforts, and if so, the size of them, and the distance they are from centre to centre, as also the materials filled in behind, or backing the wall or revetment: this, in general, may easily be ascertained, but mention is made of it, as a soft or scaly rock, which is liable to be acted upon by frost, is frequently faced with stone or brick, having the appearance of a regular retaining wall. In many cases, the section of a wall cannot be ascertained until the gallery or shaft leading to the intended chamber has been carried down to the foot of the wall: this accomplished, the charges can then be determined.

Revetments have been destroyed in a variety of ways, either by piercing a gallery

* By Lieut.-Colonel H. D. Jones, R.E.

through the masonry from the bottom of the ditch, or by sinking shafts at the back of the revetment. No precise rules can be laid down as to the plan on which the work should be executed, there being different circumstances to be attended to in each case that would require to be fully considered before the Engineer can determine which will be the best mode of proceeding with his work. In general, *time* is an important circumstance, greatly regulating the character of the operation; and that which will accomplish the object intended most rapidly, with the smallest expenditure of materials, is the one to be adopted: for instance,—at the destruction of the Spanish lines before Gibraltar, in 1810, several attempts were made to run a gallery from the interior of the work to the back of the revetment; but the sand came in so fast at the head of the gallery, that it at last brought down the terreplein, which occasioned the workmen to abandon this plan, and to adopt that of sinking shafts at the back of the revetment. This is the more usual way, and generally easiest of execution: in most cases the earth at the back of the masonry is so well consolidated as not to require frames for supporting the sides of the shaft.

In the destruction of the Glacière Bastion at Quebec, in 1828, a gallery was driven in from the interior of the work until it met the masonry, when a return was made and continued along the back of the revetment. The nature of the soil was clayey, occasionally mixed with fragments of rock and made ground, which had acquired a considerable degree of compactness. (*Vide* Appendix A.)

At Corfu, in May, 1826, to destroy Fort Schulemburg,* galleries were driven in from the face of the revetment to the rear, with returns to the right and left. (*Vide* Appendix B.)

At the siege of Burgos, 1812, a gallery was driven in through the face of the wall.

At the destruction of Fort Bourbon, in Martinique, galleries were driven from the face of the revetment through the thickness of the wall.

At Menin, 1744, the same plan was pursued.

At Almeida, in 1810, shafts were sunk at the back of the revetment.

At Sheerness, in 1837, shafts were sunk at the back of the revetment. For details *vide* Appendix C.

The foregoing examples will be sufficient to shew that there is no very exact rule for the guidance of an Officer charged with the duty of demolition; his own judgment must be his best guide. But, as deduced from the preceding and subsequent notices, *vide* Appendix E, and Table VI. included therein.

The following Tables † shew the data upon which the calculation is to be made for the charges of powder in masonry or brick-work, as prepared by Major-General Pasley for the use of the Officers employed at the Military Establishment at Chatham, and for the guidance of the Officers of the Corps of Engineers in general.

Vide 'Eprouvette.'

* When there is any doubt of the quality of the powder (as there was in this instance), it should be tested by an éprouvette.—*Ed.*

† These Tables are particularly valuable as having been deduced from experiments on excellent old brick-work.—*Ed.*

TABLE I.

*Charges and Effects produced on Masonry or Brick-work.**

To find the quantity of powder in lbs.	Multiply by	With or without counterforts.	Placed at lined intervals, or how.	Produces effects.	Remarks.
Feet. LLR^3	$\frac{3}{20}$	Without.	2-lined, placed at the back of a revetment.	Complete but moderate	Greater charges at the same, or the same at smaller intervals, would produce violent demolition.
LLR^3	$\frac{1}{5}$	With.	In the middle of each counterfort, at its junction with the escarp.	Ditto.	Ditto, ditto, ditto, and if from counterfort to counterfort is unusually great in proportion to the thickness of the revetment, place one or more charges between each at the back of the revetment.
LLR^3	$\frac{1}{3}$	——	Centre of a line of masonry at 2-line intervals.	Ditto.	To produce violent demolition, or if obliged to use greater intervals, increase the charge.
LLR^3	$\frac{4}{10}$	——	Under a foundation having equal earth on each side, 2-line intervals.	Ditto.	
LLR^3	$\frac{6}{10}$ or $\frac{1}{2}$	——	Ditto, ditto, if wood-work under foundation.	Ditto.	
LLR^3	$\frac{1}{10}$	——	In centre of mass of masonry, base circular or polygonal.	Ditto.	Use more to avoid chance of failure.

N. B.—Attack a building by the same rules as revetments; or else, merely lay your charges on the ground along one side, and cover them with $2\frac{1}{2}$ the thickness of the wall, with rammed earth.

* Abridged from Major-General Pasley's Tract on Military Mines, 1827.

TABLE II.

*Demolition of Walls of Buildings by Blasting.**

L L R is of course = $\frac{1}{2}$ thickness of wall, in feet.

The borer and jumper will always make a hole of rather greater diameter than its own width: take great care therefore as to the true diameter obtained.

Work always at an angle of 45° downwards to $1\frac{4}{10}$ L L R, which will bring you to the centre of the wall. Calculate how much more of the same hole $\frac{1}{2}$ of the proposed charge will fill, and bore so much deeper.

In the following, D = diameter of the hole in inches.
T = thickness of the wall in feet.

When D = T (the best proportion, if circumstances admit), charge in lbs. = $\frac{\text{L L R}^3}{3}$ at 2-lined intervals. Depth of hole should be $1\frac{1}{2}$ L L R.

When D = $\frac{2}{3}$ T, charge in lbs. = $\frac{2}{5}$ L L R^3 at 2-lined intervals. Depth of hole should be $1\frac{3}{4}$ L L R.

When D = $\frac{1}{2}$ T, charge in lbs. = $\frac{1}{2}$ L L R^3 at 2-lined intervals. Depth of hole should be $2\frac{1}{3}$ L L R. Bore the holes, *alternately*, from contrary sides; or else at once bore 2 from opposite sides meeting as a V, or even crossing a little below, somewhat like an X. In each hole put $\frac{1}{6}$ L L R^3; or total charge = $\frac{1}{3}$ L L R^3 at 2-lined intervals.

When D = $\frac{1}{3}$ T, proceed with the same charge as when D = $\frac{1}{2}$ T, but see that the holes from the opposite sides, forming an X, intersect each other well.

In working with smaller borers than this, instead of the V or X, bore 2 holes *close* to and parallel to each other: if needs be, they can be thrown into one.

Where economy of powder is an object, break the lower part of the wall into piers, and place the charges in them.

TABLE III.

Table of Cylindrical Holes and Charges.

Diameter.	Powder in 1 inch of hole.	Depth of hole to contain 1 lb. powder.
inches.	ounces.	inches.
1	0·419	38·197
$1\frac{1}{2}$	0·942	16·976
2	1·676	9·549
$2\frac{1}{2}$	2·618	6·112
3	3·77	4·244
$3\frac{1}{2}$	5·131	3·118
4	6·702	2·387
$4\frac{1}{2}$	8·482	1·886
5	10·472	1·528
$5\frac{1}{2}$	12·671	1·263
6	15·08	1·061

* Abridged from Major-General Pasley's Tract on Mines. 1827.

TABLE IV.

Table of Spaces occupied by certain Charges of Gunpowder.

Space.	Charge.	Space.	Charge.	Space.	Charge.	Space.	Charge.
Side of cube in inches.	Gunpowder in lbs.	Side of cube in inches.	Gunpowder in lbs.	Side of cube in inches.	Gunpowder in lbs.	Side of cube in inches.	Gunpowder in lbs.
1	0·033	19	228·63	37	1688·43	55	5545·83
2	0·26	20	266·66	38	1829·06	56	5853·86
3	0·90	21	308·70	39	1977·30	57	6173·10
4	2·13	22	354·93	40	2133·33	58	6503·73
5	4·16	23	405·56	41	2297·36	59	6845·96
6	7·20	24	460·80	42	2469·60	60	7200·00
7	11·43	25	520·83	43	2650·23	61	7566·03
8	17·06	26	585·86	44	2839·46	62	7944·26
9	24·30	27	656·10	45	3037·50	63	8334·90
10	33·33	28	731·73	46	3244·53	64	8738·13
11	44·36	29	812·96	47	3460·76	65	9154·16
12	57·60	30	900·00	48	3686·40	66	9583·20
13	73·23	31	993·03	49	3921·63	67	10025·43
14	91·46	32	1092·26	50	4166·66	68	10481·06
15	112·50	33	1197·90	51	4421·70	69	10950·30
16	136·53	34	1310·13	52	4686·93	70	11433·33
17	163·76	35	1429·16	53	4962·56	71	11930·36
18	194·40	36	1555·20	54	5248·80	72	12441·60

"In respect to the comparative effects of gunpowder upon masonry and common earth, it is sufficiently obvious that there are some particulars in which there can be no possible analogy between the two substances; as for instance, no modification of common earth whatever can be compared with the walls of a lofty building. But, in those cases in which some analogy does exist, as, for example, in comparing the effects of gunpowder behind the back of a revetment with its effects when acting below the surface of any mass of common earth capable of retaining its form permanently without being revetted, our experiments at this place do not authorize us to say that more powder is required to produce a like effect upon masonry than upon earth: nor does it appear from our experiments that more powder is required to produce a similar effect upon very stiff compact soil than upon looser earth."—*Major-General Pasley's Tract on Mines.* 1827.

TABLE V.

The Table of Charges used by the French for demolition in masonry is herewith inserted, more particularly as it appears to have been based upon the result of experiments made for that purpose, and which were found very accurate whenever tried.

Description of masonry.	Quantity of powder for A toise* cube.	Quantity of powder for A double metre cube.†
	lbs.‡	Kilogrammes.§
New, or old, masonry built or become damp where mortar is bad	15 to 16	7·94 to 8·47
Masonry of an ordinary description where the mortar is not of the best quality	18 to 19	9·53 to 10·05
New masonry, very good, and the mortar excellent	27	14·30
Old masonry, same description	30	15·89
Roman masonry, or equally solid	35	18·33

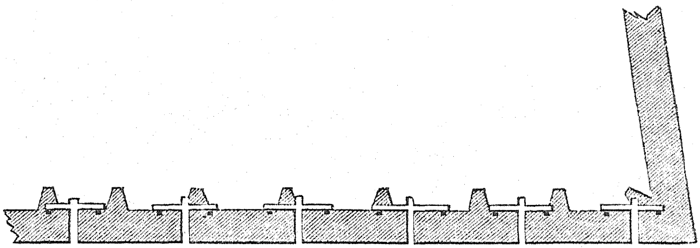
* A toise is 6 ft. 4·735 in. English measure.
† A metre is 3 ft. 3·371 in. English measure.
The cubic toise = 9·684 cubic yards; and the double metre cube is about 10½ cubic yards English.
‡ French lb. = 1·08 lb. avoirdupois. § Kilogramme = 2·206 lbs. avoirdupois.

The charges thus given will be found rather greater than those given by Landmann in 'Treatise on Mines,' calculated upon the data given by French authors:—it will therefore be safer and best to use charges calculated according to General Pasley's Table; however, as it is always interesting to know what has actually been performed, a few examples are given.

1. At Turin the face of a bastion was blown up by gunpowder.

The height of the revetment was 32 feet, the length of the face was 318 feet, the supposed thickness of the wall at the level of the bottom of the ditch was 7 feet 6 inches, the counterforts were 3 feet thick and unequally placed; no notice was taken of them in determining the position of the charges: upon piercing the wall it was found to be only 7 feet thick; the masonry was found to be of the best quality: the charges were 97 lbs., which was rather more than the quantity ought to have been, if calculated at $\frac{97}{343}$, or nearly $\frac{2}{7}$ L L R^3: the demolition was perfect; all the charges were fired simultaneously.

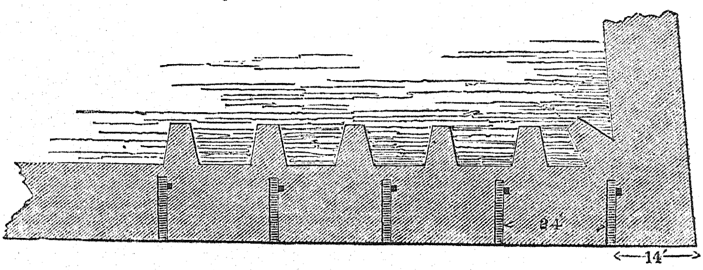
Fig. 1.—Face of a Bastion at Turin.



2. Faces of a bastion at Metz.

The revetment was 16 feet thick at the level where the charges were placed; but as it was desired to have the line of least resistance only 12 feet towards the ditch, and to have it much greater in every other direction, the first charge was placed at 14 feet from the salient angle, the second 24 feet from the first, and the same distance was observed with respect to the others as far as the orillon. A gallery was driven in from the face of the wall for each charge, and when at the proper distance, the charge was placed on the right-hand side of the end of each: by this mode the craters would be tangents to each other. The charges were 20 lbs. for each toise cube, and being fired simultaneously, the revetment and counterfort fell down in large blocks: the demolition in both cases being proved equally certain, the mode to be adopted depends upon the time, or men at command.

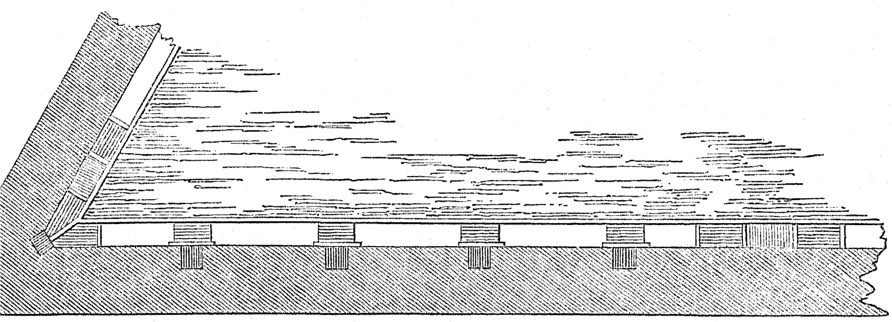
Fig. 2.—Face of a Bastion at Metz.



In this last example, where the revetment was 16 feet thick, the charges were not placed behind the wall, because by the relative weight and comparative tenacity of the earth and masonry, the line of least resistance would have been in the direction of the terreplein of the ramparts; besides, experience has shewn that it is only necessary to place the charge at ⅔rds of the thickness of the wall from the face; that is to say, a little behind the centre of gravity, in order to throw down the entire mass. The economy of time and powder by this arrangement should never be lost sight of: the ⅔rds to be measured from the exterior face of the wall.

In some cases where a gallery runs along the back of the wall, a chamber for the powder is made in the thickness of the wall, which is filled with one-half more than the usual charge, and the wall secured against the opposite side of the gallery, the intermediate spaces between the charges being left empty; the two extremities of the gallery only, being tamped for a distance equal to at least one and a half times the line of least resistance.

Fig. 3.



At Milan, in order to render the demolition more complete by throwing down a greater quantity of earth than would be the case with the simple demolition of the revetment, the following plan was adopted: the wall at its base was 9 feet thick, counterforts 6 feet, 18 feet from centre to centre; the charges to destroy the wall were placed in the centre of the counterforts, and the other charges were placed in the earth behind the wall, at the distance from the charges in the counterforts, of 18 feet for the line of least resistance; the charges in the counterforts were calculated according to the quality of the masonry, and the distant charges were 300 ℔s., that is, rather more than half of the entire charge, calculated at 12 ℔s. per double metre cube.* (Vide Table V.) The explosion caused a great quantity of earth to be thrown out: to have removed the same by shovel and barrow would have cost much more than the price of the powder.

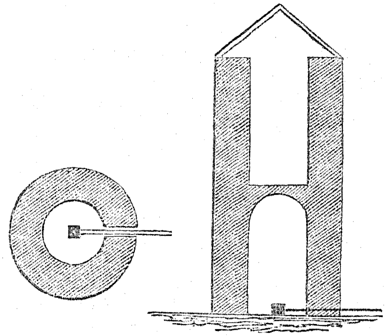
TOWERS.

In the demolition of towers, some examples will be given to shew what has been accomplished with success. A round tower at Ormea, 55 feet high, the walls 7 feet thick, and its interior diameter 12 feet; an arch 25 feet above the ground divided the tower into two parts; a box, containing 102 ℔s. of powder, was placed in the middle of the room on the ground-floor, which was filled with earth; the fuze was

* About 10½ cubic yards English.

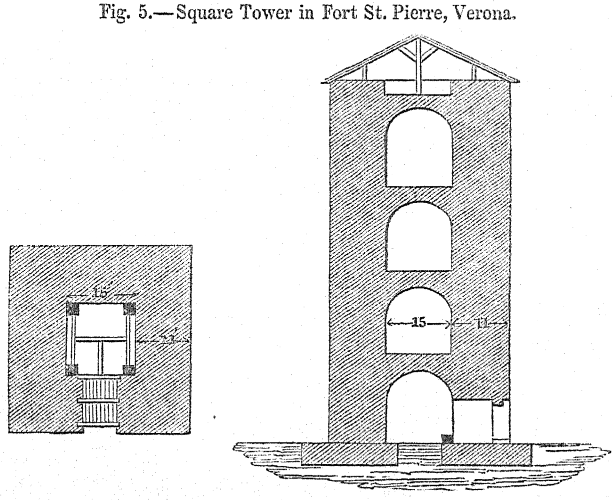
conducted from the powder to the outside through a loophole. After the explosion, the yard of the castle was filled with the ruins, without any of the neighbouring buildings being in the slightest degree injured.

Fig. 4.—Round Tower at Ormea.



A square tower, 75 feet high, 15 feet interior side, and of which the walls were 11 feet thick, stood isolated in Fort St. Pierre at Verona: this tower was divided into four equal parts, or floors, by four arches; the upper one supported the roof. Four boxes, each containing 400 lbs. of powder, were placed at the four angles of the ground-floor, which was carefully filled with earth, wood, and stone; the fuze at the point of junction from the four charges was carried through the doorway, which was very firmly blocked up: the tower fell in large blocks, and no fragments were thrown beyond the small circle in which the ruins were contained, and which would scarcely have been large enough, had the tower fallen down of its own accord, without any explosive power having been employed.

Fig. 5.—Square Tower in Fort St. Pierre, Verona.



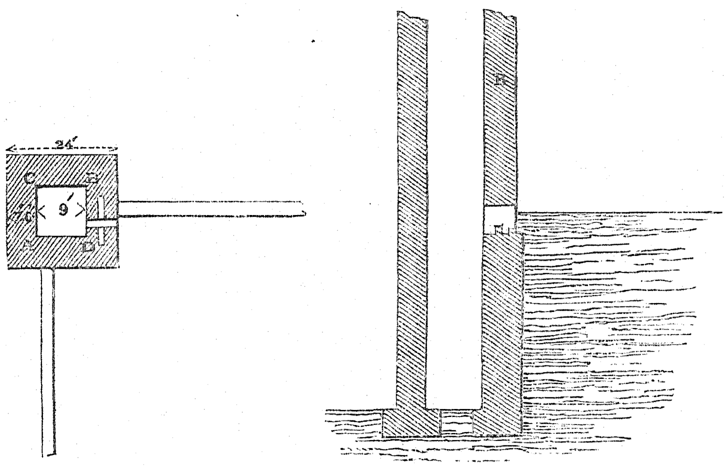
The masonry of this tower was of the best description: for 15 feet from the ground, the walls were of cut stone, and for this reason it was thought necessary to calculate the charges at the rate of 35 lbs. the double toise * cube, and to consider

* About $77\frac{1}{2}$ cubic yards English.

the charges as isolated, notwithstanding the spheres of the explosion would cross each other: it was supposed that the tower would not have been thrown down if the formula for conjunct charges had been adopted: as none of the materials were thrown out, and as the tower fell in large blocks of 6, 9, and 12 feet of a side, it must be concluded that the charges were not too great: this proves that in fixing the quantity of powder, attention must be paid, not only to the quality of the masonry, but still more to the height of the walls when they are very thick, and exceed 30 or 40 feet. When towers are joined to the enceinte of a place, the adjoining masonry should be mined, as well as the tower; if not, there is a risk of only cracking the outside, while the inner part remains uninjured.

The following account of the destruction of a tower at Verona is interesting, as shewing a successful mode of procedure when there are buildings situated very near to the tower to be destroyed. The tower was 75 feet high on the side next the town, built on the side of a steep hill; its base was 40 or 50 feet above the roofs of the nearest houses, which were not more than 40 yards distant, the ground rising suddenly towards the fort; the face B, opposite to that facing the town, was only 40 feet high. From the fear of injuring the houses, it was determined to destroy part of the tower without throwing down the entire building: a gallery was made by a little door, which was in face B: if there had not been a doorway, the entrance to the gallery must have been made through the wall; a chamber was made in the diagonal of the angle D, and a second at two-thirds of the same face B D, which was, as well as the other faces, 24 feet of a side, outside measurement; the thickness of the walls was 7 feet 6 inches. It was considered sufficient to place 50 lbs. of powder in each of the two chambers; the fuzes were joined so as to cause simultaneous explosion: it was expected that by this arrangement the entire face B D, and part of face A D, would be completely destroyed, and also a part of B C, leaving the remaining portion standing: these expectations were more than realized, though no injury occurred to the houses.

Fig. 6.—Second Square Tower at Verona.



The towers in the works at Almarez, in 1812, were blown up by Lord Hill's corps, by placing 450 lbs. on the centre of the floor; and for the greater security of the miners, the powder was exploded by means of quick-match, and a train carried up to the first-floor, at which level the entrance gate was placed. The towers were

utterly demolished by the explosion: it is to be regretted that dimensions cannot be given.

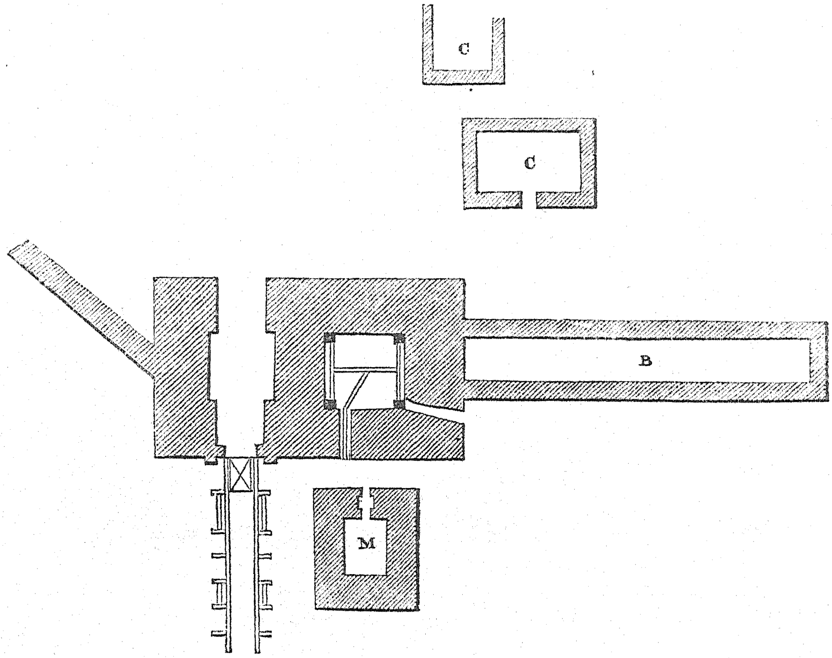
During the last war, in cases where no powder could be obtained, the ancient mode of mining was resorted to, and towers were thrown down by cutting away the earth under the foundations, and supporting the building on blocks of wood, the interstices between them being filled with combustible materials well ignited: when the blocks were consumed the building fell, for want of support. This method has been also practised for the demolition of revetments.

The following account of an explosion which took place at the Fort of St. Felix at Verona, to destroy simultaneously two adjoining towers, and other adjacent buildings, cannot fail to be interesting to an Engineer.

The extraordinary effects of this explosion would alone be sufficient to warrant the mention of it, even if it were not necessary to speak of the additional charges that are sometimes employed to increase the violence of the commotion, and to destroy at one blow groups of objects that want of time prevents from being destroyed separately.

One of these two towers was at least 85 feet in height; it was square; its interior side was 16 feet, and the walls 12 feet thick: at its left, as seen from the outside, there was another tower, which served as an entrance gate, not quite so high, but with walls as thick as the first. In front of these two towers, at about 39 feet, there was a sort of counterscarp, not revetted, in height 20 feet; and in the ditch formed by it, and exactly facing it at 6 feet from the great tower, was a square powder magazine (M), of which the interior side was 12 feet, and the walls 6 feet in thickness: to the left of the tower gate, and to the right of the great tower, were two great walls, not backed with earth; to the last of which was joined a large building (B), that had served as a lodging for the Commandant of the Fort.

Fig. 7.—Tower, &c., at Fort St. Felix, Verona.



As the destruction of these masses bit by bit required more time than could be allowed, it was proposed to overthrow the whole by a single mine.

The great tower having one room, the floor of which was on a level with the ditch and the powder magazine (M), it was resolved to place the charge there, divided in four boxes of equal size, placed at the four angles, and to make the total quantity five times the necessary charge to overthrow only the great tower. Its walls, as already stated, were 12 feet thick, and the quality of the masonry required 39 lbs. of powder for each double metre cube. (See Table V.) Thus each box, with reference to the tower alone, would have required 553 lbs.; but which, $\times$ 5, gives the intended charge for each corner, or 2765 lbs.; or the whole $4 \times 2765 = 11060$ lbs. Circumstances, however, caused it to be reduced to 8776 lbs., that is to say, to something less than four times the simple charge of 553 lbs. $\times 4 = 2212$ lbs.

These four boxes having been placed at the four corners of the room, it was filled with earth, stones, and wood, the door and embrasure were strongly barricaded, and the whole was then fired.

The result of this explosion was that the two towers were *pulverized*, the powder magazine crushed, as if the charge had been placed within it; the wall of the enclosure to the left, thrown down for the length of 130 feet; and that to the right thrown down 52 feet in length, entirely razed, as was also the building (B); other buildings (C) that were bomb-proof, and distant from the centre of the great tower, from 45 to 65 feet, were destroyed or shaken in such a manner as to render them perfectly useless. This explosion (which may lead to reflection and useful calculation on overcharged mines applied to demolition) was accompanied by no accident. One single fuze flew out by the doorway of the tower which was charged, and the explosion carried some rubbish to the distance of 160 feet.

The destruction of a place consists not only in overthrowing the fortifications, but also in destroying the interior military establishments, such as powder magazines, cisterns, arsenals, &c.: we shall therefore give an account of the manner of destroying them.

Fort Conception, on the road from Almeida to Ciudad Rodrigo, was successfully destroyed by gunpowder by Captain Burgoyne,* in the year 1810, after the capture of the latter place by the French army under Marshal Massena.

Fort Conception is of a square figure with two advanced works, one of a lozenge shape, and the other that of a trapezium: the bastions were full, the curtains casemated, and a small casemate in each flank. It was proposed to sink a shaft on the line of the capital, nearly to the level of the bottom of the ditch, and a gallery carried from the bottom of the shaft near to the escarp wall of each face, with a return for two chambers. This arrangement was necessarily altered, from the difficulty of carrying it into execution; it was therefore decided to take advantage of the casemates in the flanks, which were about 12 feet cube: the ravelins were also casemated, and 5760 lbs. of powder in barrels were lodged in each, a few portions of 1440 lbs., that is, one in each face and flank.

The detached works were full of casemates; a charge of 3840 lbs. was lodged in one of the angles of the gorge, and the other advanced fort, which had two circular casemates in the shoulders of the work, was loaded with 2800 lbs. of powder. The mines, when fired, exploded with full effect; good breaches were formed in the faces of the bastions, and small ones in the flanks of the ravelins: nothing remained standing but a small part of the salient angle: the lozenge-shaped outwork was as if cut in two parts diagonally; the half in which the powder was

* Now Major-General Sir F. Burgoyne, K.C.B., Inspector-General of Fortifications.

lodged was entirely blown down, and of the other work the front face and great part of the flanks were totally destroyed.

MAGAZINES.

When time will permit, a powder magazine is destroyed by a series of mines, placed in the centre of the thickness of its piers, and of its gable: these mines are then charged, according to their line of least resistance, and with regard to the quality of the masonry; they are then brought to act together, and the fall of the vertical walls necessarily involves that of the arch.

When there is no time to spare, the following process is employed, which requires no preliminary work.

The powder is placed in a heap, on the floor of the magazine; the doors and windows are fastened, and it is then fired by means of a hose which reaches from the powder to the outside of the building. As to the quantity of powder that should be placed in the heap, knowing the interior length and breadth of a magazine, and the thickness of its piers, a revetment imagined of the same thickness, and the same quality of masonry as the piers, and of equal length with the interior line of the piers and gables,—find out the number of isolated mines that it would be necessary to place behind this 'revetment' to throw it down, and what quantity of powder would form the united charges of all these mines: this quantity of powder, with the addition of half as much again, igniting in the interior of the magazine, will destroy it, without carrying the rubbish ten paces beyond it.

It is not necessary, when determining the strength of the charge, to take into consideration the height of the powder magazine, because the mines being generally as low down as they can be conveniently placed, the line of least resistance refers to the thickness of the wall rather than to the height; and the ruin of the upper part of a magazine is involved in that of the lower portion.

When the length of a magazine is greater than its breadth, it would be well to divide the powder that is placed on the floor in two or three equal heaps; and should the magazine in question have lateral passages, as is sometimes the case, a portion of the charge should be distributed in those passages: care should also be taken that these heaps may all ignite at the same instant.

BUILDINGS.

Having cited numerous examples, shewing the mode by which magazines may be destroyed, and which may be classed under the head of *quiet** demolition, we shall give some extracts from the Journal of the memorable Siege of Saragossa in 1808, when the French General, in consequence of the little progress he had made by an open attack against the large convents and buildings, resolved to proceed by a covered attack, that is, by mining, which henceforward was the principal operation throughout the siege; the artillery being employed as an auxiliary. It is to be regretted that more details are not given, as to the thickness of the walls, and the rule by which the charges were calculated: the Engineer, however, will readily perceive of how great importance it was towards the reduction of the Place that the explosions should merely produce a limited result,—that was, in general, to form a practicable breach in the face of the building, by which a column or body of troops could enter without losing the benefit afforded by the remaining walls to cover their approaches or communications.

"We took possession with great difficulty of the block of houses contiguous to

* In contradistinction only to violent and hasty demolition.

Santa Engracia. The Sappers worked across the first small street to the left of it, and were able to get into a room on the ground-floor of a house opposite to it: however, the enemy held most determinedly the cellars, the upper stories, and the other parts of the building; so that not being able to drive him out of it, it was blown up. The miners placed 200 lbs. in the room which they occupied, and set fire to it: the house was thrown down, and by the consternation produced by the explosion we obtained possession of the whole block of houses.

"Towards Santa Engracia we blew up several houses; by the explosions a great number of Spaniards were buried in the ruins. Notwithstanding, the mines did not produce upon the minds of the enemy so great an effect as we expected: these enthusiasts, resolved to bury themselves in the ruins of their houses, did not permit themselves to be frightened by our firing of the mines; they did not abandon the buildings, torn and cracked by the explosions; and the briskness of their fire hindered us from establishing ourselves within them.

"Experience taught us that houses entirely thrown down by the mines were often an obstacle to our progress, since the ruins of the houses no longer afforded cover to proceed with the attack of the neighbouring houses; we could no longer cross these ruins, but with infinite trouble and danger. The Officers of Engineers calculated the charges of the mines in such a manner as to form a breach without throwing down the houses; the mines were particularly used for breaching the convents and the great buildings, which formed a series of citadels in the interior of the city.

"In general, when the Spaniards had been forced to abandon their houses, they set them on fire, so that the conflagration might establish a barrier between them and us, whilst they could establish means of defence at a little further distance. The combustion of the houses at Saragossa, in the construction of which there is very little wood, is very slow and difficult, and does not communicate to the adjoining buildings: we were obliged to endeavour to extinguish these fires under a shower of hand-grenades, or to wait several days until the houses were entirely consumed, before being able to advance.

"We took several blocks of houses in front of Saint Augustin, by opening the walls, either by blasting, by the mine, or by sap.

"When the enemy's miner appeared desirous of annoying the works, our miners hastened to load the chamber with 1500 lbs. of powder each, and fired them; that against St. Francis formed a breach which was scarcely practicable. The two mines against the hospital produced every effect that could be desired, and we possessed ourselves of two-thirds of this building, which from the first-floor was an entire mass of ruins.

"At the centre attack, our miners had entered the cellars of the hospital to cross the Santa Engracia Street by three galleries, but they were obliged to abandon them in consequence of the explosions of the hand-grenades extinguishing the workmen's lamps.

"In the cellars of the hospital, a mine was loaded with 3000 lbs. of powder; fire was communicated to it, after having drawn a great number of Spaniards within the sphere of action: the explosion was terrific, and threw down a part of the building.

"Two mines to make a breach in the University were loaded with 500 lbs. each, but did not produce the effect desired.

"It was desired to open by a mine one of the houses near the Cosso, but too much powder having been used, the house was entirely destroyed, so that no cover would be obtained to reach the adjoining house.

"A tower without any outlet prevented us from penetrating to the left of the block of houses: a passage was opened by blasting, and to drive the Spaniards out

of the rooms which they occupied, shells were rolled into them: the explosion of one of these shells caused all the arches to fall down to the cellar.

"The miners made two chambers under the University, and loaded them with 1500 lbs. of powder each; the explosions formed two large breaches.

"A breach was made in Trinity Church by blasting.

"At the centre attack, the miners fired a chamber charged with 1600 lbs. of powder, placed under the great house with turrets; the half of the front was thrown down with a frightful crash, and buried fifty Spaniards under the ruins."

In 1824, after the great fire at Edinburgh, Lieutenant Head, Royal Engineers, (the present Sir Francis Bond Head, Bart.,) performed a very successful operation in bringing down some very high walls by the effects of gunpowder: he states, that he bored five holes in a line parallel with the base of the building, and at a height convenient for the men to work; that the jumper was driven slanting into the wall, and penetrated one inch farther than the centre of the wall, which was three feet thick, in order that the powder should blow out both sides of it: in every instance the powder was imbedded in a stone, and not in mortar. In the five holes there were $4\frac{1}{2}$ lbs. of powder, but as only holes Nos. 1 and 2 exploded, the others having been smothered, the effect was produced by only $\frac{2}{5}$ths of that quantity. To insure the direction in which the walls were to fall, the ruins were first braced and bound together by chains, ropes, &c. A detailed account was published at the Establishment at Chatham in 1825.

CISTERNS.

What has been said respecting powder magazines applies equally to all bomb-broof arched buildings: a cistern thus arched can be destroyed either by mines or heaps of powder, although it may be filled with water at the moment that its destruction is intended. In the latter case, a raft is placed on the water in the middle of the area of the cistern, which is capable of supporting without being submerged a box containing the powder required for the proposed operation; and by means of troughs leading from the box, and fixed so as not to be deranged by the combustion of the hose that they contain, and by which the fire is carried to the powder: a vast cistern was destroyed in this manner at Ehrenbreitstein.

Cisterns being generally sunk in the ground for a portion of their height, in operating as above described, the arch only may be destroyed; but to render the destruction more complete, when time will permit, charges are placed under the pier most accessible: the destruction of this pier brings down the arch, and consequently renders the cistern useless until rebuilt.

There is also another plan which may be adopted if time will permit for its execution; which is, to sink a shaft and drive a gallery under the bottom; which, being charged with sufficient powder to embrace the entire area within the circumference of the crater after the explosion, the destruction will be complete.

Without regard to the time which the Engineer can command, it may be observed that the first method of placing the powder in a heap, is best when the cisterns are cut out of rocks; and the last two when the upright walls or piers rest against the earth.

Walls may be destroyed by boring holes in them at the four corners, just above the water standing in them; charging the whole with 10 or 12 lbs. of powder, and firing them simultaneously: if necessary, recourse may be had to a second operation of the same nature.

Another mode is to suspend a box, or barrel, containing 200 lbs. of powder, just above the water: the explosion will generally prove effective.

As it is very difficult to destroy a cistern cut out of rock, the next best thing to do is to fill it with materials and rubbish of any description that may be at hand.

Arsenals, hospitals, barracks, in short, every military building, may be destroyed when there is time; and it is necessary to economize powder by the following mode:

Remove all the wood-work, such as doors and windows; after which, cut away as much of the foundations as may be safe, leaving at each of the four angles of the building a column as broad as the wall is thick: if charges are lodged in these columns, the result cannot well be doubtful.

When there is not time to perform the above operation, place a quantity of powder in the cellar (or on the ground-floor, if there is no cellar). If it is difficult to determine the quantity of powder for the effect desired, place a charge in one of the rooms on the ground-floor at one end of the building; see the effect produced by the explosion, and then determine whether it will be necessary to increase or diminish the charge: in this mode of operating the ceilings should not be disturbed, and all the doors and windows on the ground-floor firmly shut and secured.

At Flushing, in 1809, a fine brick building in the dockyard, four stories high, with a strong cross wall in the centre in the direction of its length, was ordered to be destroyed: charges of 30 lbs. were placed in each of the four angles, as well as at the junction of the cross wall; the charges were not fired simultaneously; the effect was to bring down a considerable portion of each face of the building, but the charges at the junction of the cross wall were not sufficiently great to affect the superincumbent weight, as the charge blew away the loading which had been placed outside, but without injuring the wall; the loading in each case being the same.

BRIDGES.

The destruction of bridges as a military operation is generally required to be undertaken under peculiar circumstances; little time allowed for performing the work, and few hands or means to execute it. It frequently happens whilst an army is before an enemy, and closely pressed by him, that a bridge is required to be destroyed, to prevent his pursuing the retreating body, or to arrest his progress, in order to gain time for the movements of the army. In the retreat of the British army from Burgos, upwards of twenty bridges were destroyed, with the exception of two or three, which were only partially injured from want of time; the destruction of the others was perfect: in many cases the train was not lighted until the enemy were actually on the bridge; in others, as at Cabezon, the enemy's pickets were two or three days at one end of the bridge; an Officer of Engineers during that time waiting with a lighted slow-match, prepared to fire the train the instant the enemy should attempt to push on to the bridge; at the same time cautioned not to be deceived by false alarm of his advance. In many instances an Officer of Engineers was unexpectedly called upon for the duty of destroying a bridge, sent off at a moment's notice 40 or 50 miles, to be followed by a muleteer carrying two barrels of powder; without a miner, or tools, other than what could be collected in the neighbourhood of the bridge to be destroyed, and with such assistance in manual labour as could be procured on the spot, or by the assistance of some of the Dragoons forming his escort. The duty an Officer is thus called upon to perform is one of a most important nature; great interests are at stake; the manner in which it is executed may have great effect on the result; the fate of a campaign may depend upon it.

The following details will point out the mode pursued in the destruction of bridges during the Peninsular war under the Duke of Wellington. The bridges in

general were stone, with arches from 20 to 40 feet span, semicircular, of one stone (18 inches to 2 feet) in depth: the loading of the arches was generally solid masonry. The object desired was to destroy one arch, and in order to arrest an enemy as long a period as possible, the largest arch, where there was deep water, was selected, unless want of time, or powder, made it advisable to choose another which appeared weaker than the others. The following modes were usually adopted:

1st. By sinking a shaft in the roadway, generally a few feet to the right or left of the centre of the width of the bridge, down to the haunch of the arch, with a very short gallery ending in a chamber, so as to lodge the powder in the middle of the width of the bridge under the roadway. If the charge was to remain for some time before being exploded, (it very often happens that a bridge is ordered to be prepared for destruction many days, sometimes months, if in a defensive position, previous to the order being given for firing it,) precautions were taken to secure the powder from damp, or wet,* either by putting it in a wooden box prepared for it, or other which may be at hand at the moment: the train was then fixed to the box, and brought to the surface of the road up the shaft, which was then solidly and compactly filled in with the material which had been taken out, and if thought necessary, some of the stones of the parapet were laid over the mouth of the shaft to increase the resistance: to the end of the train was fixed a piece of portfire. If a corps or division of the army was to pass over after it was prepared for destruction, the train, or hose, was brought within a foot of the surface of the roadway, and then carried in a groove, cut on purpose, to the side of the parapet, the groove being filled in so that the road remained clear for the passage of troops or artillery without the chance of the hose being disturbed: precautions were taken to drain the roadway in case of rain, in order to preserve the train from getting injured by wet. Where a bridge is very wide it may be proper to divide the quantity of powder necessary for destruction into two charges, by sinking shafts at the proper points, according to the breadth of the bridge: this is likely to be attended with failure: it has happened that only one charge takes effect, leaving half the arch, which still affords a passage for troops. Several modes have been suggested for breaking down an arch, such as laying a quantity of powder upon the crown of the arch, so that the concussion may break it: this, if effectual, will require a very large charge, much greater for an arch of good masonry than 100 lbs., which the French state is sufficient; probably more than could be obtained or spared for this method.† Another is by suspending the charge under the arch: this is likely to be ineffectual from the difficulty of drawing up or firing the charge near the crown of the arch. In some cases a gallery has been driven into a pier at the level of the springing of the arch: there are difficulties attending this plan which make it unadvisable to adopt it. At Duenas,‡ in 1812, on the retreat from Burgos, the rear guard of the army was closely pressed by the enemy; the bridge was of solid masonry from the arch to the roadway; the miners had only time to strip off some of the pavement, and lodge two barrels of powder in the hole, covering them as hastily as possible with the small quantity of material at hand: when fired, the effect was to break down the entire breadth of the arch, making a gap of 15 feet. And in the Lines of Torres Vedras, a bridge was destroyed in a similar manner, by merely placing the powder on the crown of the arch, without any loading whatever.

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* When any of these mines fell temporarily into the hands of the enemy, they were invariably emptied for the sake of the powder.—*Ed.*

† Still perhaps worthy of further consideration and experiment.—*Ed.*

‡ The bridge in Plate XI. 'Field Sketching.'

At Port St. Maxance, in 1814, only one-half of the arch was broken down by the explosion, leaving the other, affording a free passage across it: the same result attended an explosion of the bridge at Ruivaes, in the north of Portugal, when attempted to be destroyed by the French during the Peninsular war. It is considered advisable, in placing the powder, to put it into an oblong form, rather than in a cubical mass; as by the latter mode it not unfrequently happens that a portion of the arch may be thrown down, as at Port St. Maxance. Where the bridge is narrow, there can be no necessity for sinking the shaft much deeper than half the width of the bridge, as want of resistance at the sides will render the additional vertical resistance of no importance.

A failure occurred during the Peninsular war, from having sunk a shaft down to a pier with the intention of destroying two arches: although great perpendicular resistance was gained, the effect was to blow out the sides of the pier, leaving the arches perfect.

In some old bridges, very large and substantial cut-waters will be found, which had been constructed subsequent to the erection of the bridge: these will be found to offer great resistance, and contribute very much to produce the effects above described. In the destruction of two bridges on the Shannon, in 1845, the cut-waters being very substantial, and running very high up the face of the pier, were obliged to be taken into consideration when calculating the charges. (See fig. 14.)

In the Peninsular war, when there was time, the mines were loaded with every necessary precaution, the powder placed in a box, the hose laid in a wooden trough, and when required to remain any time under ground, the box and trough were well pitched, if there were means, and covered with straw, tarpaulin, &c., to preserve the powder dry: when pressed for time, the barrels were placed in the chamber, or the powder tied up in a piece of tarpaulin, or in linen bags: the hose was sometimes laid without a wooden trough, but with care that it would not be choked by the filling in of the mine. Saucisson or hose is easily made and carried. Bickford's patent fuze is an excellent material for firing mines;* the only objection is, the length of time it takes to communicate with the powder: in using it, great care should be observed to cut off a piece, and to examine if the end at the part cut off is well and properly filled with the composition. In blowing up the bridge at Athlone, in 1845, from want of attention to this circumstance, a good deal of delay and suspense occurred, and the person in charge was obliged to go and cut the end of the fuze, and light it a second time, before the explosion took place. It has been stated as objectionable to use two charges, where the effect desired could be obtained by one: but circumstances may arise which might make it advisable to do so, in order to gain time; for instance—in sinking the shaft in the centre of the roadway of the bridge across the Shannon at Carrick, the workmen came upon the spandril wall, which was of excellent masonry, and caused great trouble to sink the shaft through it, as well as consuming a great deal of time.

In destroying bridges by gunpowder in the field, the quantity was never determined by any fixed data for calculating the charge; and, moreover, had there been any rule established for so doing, it would never be wise, or prudent, in the Engineer employed to destroy a bridge, to run the risk of failure by being too precise; and to avoid the possibility of such, and to insure success, powder must be used freely: nevertheless, where there is no question of time, the Rules and Tables given in this Paper may be applied with advantage.

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* Especially for charges under water, taking care to use the appropriate description. *Vide* 'Fuze.'—*Ed.*

On the Shannon, where several old bridges had to be removed, consequent upon the improvements making in the navigation, it was considered an excellent opportunity of testing the accuracy of the data given by General Pasley, and more particularly as these bridges being situated in the centre of towns, with dwelling-houses on each bank of the river, abutting upon the ends of the bridge, large charges could not be used, without running the risk of injuring them: the result appeared to prove that the quantity of powder calculated in pounds of $L\,L\,R^3 \times \frac{1}{3}$, will be found just equal to the duty of blowing down the pier and the greater part of the two adjoining arches without dispersing the materials. This, in some cases, would be objectionable, as the mass of stone, &c., thus falling into the water-way of the arch, might, if the river was not very deep, greatly facilitate the passage of troops, and certainly aid very much in the operation of repairing the bridge. This would be an additional reason for using a much greater charge than the rule prescribes, in order that the materials may be dispersed; and if the explosion does not take place until an enemy is close upon the bridge, he will be liable to lose a great number of men by the falling stones. There is also another reason which may be urged for using large charges: the fracas, and noise of the explosion, and falling materials, will have a great effect upon soldiers, who, if accustomed to silent demolition, would not hesitate to rush on, and attempt to disturb the train, which might have been done on the bridges at Athlone and Carrick, where the demolition was silent but perfect, scarcely any report from the explosion, and unattended by danger to any person who might have been standing upon the bridge, just clear of the line of fracture of the arch.

For details of the demolition of the bridges at Banagher and Rooskey, *vide* Appendix D.

BARRIER GATES.

The Petard (the ancient machine or instrument for blowing down gates, or barriers, at the entrance to a fortress, causeway, or building,) has for many years been in disuse in the British Service, having been found too unwieldy an instrument for attacks by surprise, or even at any time, under any circumstances: a bag of powder has been substituted, and it is believed on every occasion, where applied, with success.

Many experimental trials have been made at the Royal Engineer Field Establishment at Chatham, and also at Quebec. In the Professional Papers, vol. vi., of the Corps of Royal Engineers, an account is given of two experiments made at Quebec in the year 1840.

The first experiment was against the outside of a pair of sallyport gates: the gates were 4 inches thick, 2-inch oak doubled, fastened inside by an iron strap 18 inches, $2\frac{1}{2}$ inches, by $\frac{1}{2}$ inch, and further were secured by two bars of $1\frac{1}{8}$-inch round iron, fixed at one end by staples to posts in the rear; the other end was attached to the gates near the centre. The quantity of powder used was 50 ℔s., sewn up in a leathern bag; it was suspended to one of the gates on the outside near the centre; the effect of the explosion was to destroy that half of the gate to which the bag was attached; the other was not so much injured: the gates were opened sufficient to allow four or five men to pass in abreast.

The second experiment was attended with much the same success as the first: but it appears evident, as very justly remarked by the Officer* who conducted the experiment, that a greater charge ought to have been used by 10 or 15 ℔s., it being evident that had the gates been equal in strength to the entrance gates of fortresses,

* Lieut. Simmons, R. E.

it is most probable that an assaulting column would have had great difficulty to pass through the opening.

It appears from these experiments that the piers of the gates, although of green masonry, were uninjured by the explosion, and that the effect of the powder was chiefly at the point of suspension: hence, from the details given, it may be presumed that if the gates had been more strongly fastened, or if there had been iron stays at the top and bottom rails, a mere hole would have been blown through the gate, unless the charge had been doubled; in fact, the gates were only partially blown open, though the injury caused by the explosion was sufficiently great to enable a few men to pass through, which is the principal object to be attained: this is more easily, quickly, and better effected by a bag of powder than by any other means at present in use. The East India Company's Engineers have had opportunities of thus applying bags of powder. At Ghuznee, in 1839, a charge of 300 ℔s. was used with success, divided and placed in twelve sand-bags, with a hose 72 feet long: it is supposed (although the account does not state it) that the bags were merely laid down on the ground at the foot of the gate, and there exploded.*

Also, in the late war in China, at the storming of Chin-keang-foo, 160 ℔s. of powder, in bags, placed on the ground, blew a large two-leaved gate off its hinges, and flung it, almost uninjured, several feet back into the archway, though this last had been in a great measure filled up with bags of grain, &c., to obstruct the entrance.

LOCKS AND GATES.

In the principal maritime fortresses, there are generally large basins, in which men-of-war remain afloat, the water in them being retained by large gates, with a chamber for the ingress or egress of the vessels. A description of the operation† of destroying the chamber between the lock-gates at Flushing is herewith given: the result was every thing that could be desired; the work was completely destroyed, and the explosion effected its work, quietly, and without the slightest injury to the adjacent houses.

"The length of each pier was 128 feet, the thickness varied from about 27 to nearly 33 feet, and the height, above the floor of the entrance chamber, was 26 feet; the whole of solid brick-work, except a small arched channel or culvert, which ran longitudinally through the upper part of each pier.

"The object being to render these piers unserviceable, with the least possible injury to the town of Flushing, it was proposed so to place the charges that the foot of each wall should be blown into the entrance or lock chamber, and that the upper part of the wall, instead of being thrown upwards by the immediate effect after explosion, should fall as its consequence, or be so rent as to be incapable of partial repair.

"The position fixed upon for the charges was two feet above the floor of the lock chamber, and with a line of least resistance towards the face of each pier of 9 feet.

"The explosion was to take place at low tide, when there would be 7 feet depth of water in the entrance chamber.

"Four mines were determined for each pier, to be equally distributed and fired together; the charge of each to be three barrels of gunpowder, or about 270 ℔s.

"A shaft, 7 feet square, was sunk for each mine in the ground mmediately at the

* When the quantity of powder admits of its being hung to the centre of the gates, as was the case in the Quebec experiments, the party should be provided with a large gimlet or two, as the readiest and quietest way of suspending the powder-bags.—*Ed.*

† Abridged from Colonel Fanshawe's Report.—Corps Papers, vol. ii.

back of the piers, and upon reaching the required depth in each, a gallery 4 feet 6 inches high, and 2 feet 6 inches wide, was driven through the brick-work to the position for the charge.

"The general average of work accomplished by the miners was about $1\frac{3}{4}$ inch length of gallery per hour.

"Having reached the length intended for each gallery, a return was made for the chamber, of which the following is a section:

"The boxes to contain the charges were in the clear $19\frac{1}{4} \times 19\frac{1}{4} \times 22\frac{1}{4}$ inches, made of $1\frac{1}{2}$-inch deal, the bottom covered with tarpaulin, and the cover made to fit exactly with ledges.

"The auget was fixed to, or rather housed into, the centre of the side of the box towards the gallery.

"A slight bridge was thrown across the entrance chamber, from pier to pier; the mines were connected together by the hose, and fired by a portfire equidistant from the centre of each charge, allowing 4 inches for every right-angled turn.

"The mines were exploded at low water, and the flood-gates were opened: the effect of each charge (excepting two on the eastern side, where the powder had become damp, and the explosion consequently only rent the pier,) was to blow out the bottom of the wall, and to destroy the adjoining part of the floor, which was of oak: the bottom of the piers being thus removed, the upper part almost immediately fell.

"So completely was the desire that the town should not suffer fulfilled, that not even a square of glass was broken in the lock-house, situated about 30 feet in rear of the western pier, whilst the effectual destruction of the piers themselves was accomplished."

References upon any of the above subjects may be made to the Professional Papers of the Royal Engineers; Sir John Burgoyne's Paper on the Destruction of Bridges, in Part I., pp. 193, 194; Sir John Jones's Sieges; Landmann, Pasley, Gompertz and Lebrun, Mouzé, Rogniat, &c., &c.

BOOMS.

In giving the following decisive experiment as to the facility of destroying booms *when unopposed*, it is right to refer to the third paragraph of the article 'Boom,' in which it is expressly stated that they must never be left unobserved or unprotected.

"Another interesting experiment took place yesterday off the *Excellent*, Captain Chads, on the most speedy and efficacious mode of destroying a boom, which might impede the progress of boat squadrons in narrow rivers, as in the case of the recent attack on the pirates of Borneo by the squadron under Rear-Admiral Sir Thomas Cochrane.

"The first experiment took place on Friday last, but was on a smaller scale than the present, consequently not so convincing or successful in its results.

"On the present occasion two line-of-battle-ships' lower masts* were taken from the old mast-pond, and moored at a short distance from the *Excellent*. Six turns of small chain lashing secured the two spars in the centre; the ends of the spars were secured by two half-hitches of chain, and two parts of the chain cable ran along the spars, and were secured in the same manner round the opposite extreme. The spars being thus secured, as if at the entrance of a river or creek, to prevent intrusion, the operations now commenced to dislodge them:—A breaker, containing 56 lbs. of gun-

* Diameter 27 inches, length 90 feet.

powder, was brought to the spot; at one end was 8 inches of portfire passed into it, over which was secured a copper tube made perfectly water-tight; and two threads of quick-match being attached to the upper end of the portfire, and the opposite extreme brought through to the mouth of the tube above the water, they were ignited, and the breaker being thereupon hauled and secured immediately under the spars, a sufficiency of time (eight minutes) was provided for the boat to get clear of the mass before the portfire reached the powder, which it did in the time above mentioned, when a tremendous explosion took place. On examining the spars and their fastenings, afterwards, the following was the result: 14 feet out of the centre of both spars was shivered into atoms, with one of the chain lashings blown up with the timbers. The same experiment was afterwards repeated upon the shorter end of the obstruction, under the parts of the chain cable, the result of which was that the whole of the spars were blown to pieces. These experiments were highly successful and satisfactory.

"This morning a further experiment was made upon the two long ends of the same spars, with the chain cable wound round them, and a hemp (13-inch) cable hove 'taut' in the intervals, the rest of the arrangements being the same as yesterday, except the quantity of powder, 112 lbs. being used to-day. The result was the total demolition of both spars, the chain cable was thrown to the bottom, and the hempen one blown away. Thus the success of the experiments is most unqualified and important. They were performed at the desire of Lord Ellenborough, who had expressed to Captain Chads, in a letter, his opinion upon the importance of Naval Officers becoming acquainted with the safest and most speedy method of removing such obstructions as those offered to the China squadron on the late occasion of the conflict with the pirates in the Malvodo river."—*From the 'Times' of* 15*th January,* 1846.

APPENDIX A.*

Demolition of the Left Face and Flank of the Glacière Bastion, in 1828, *by* 5*th Company of Royal Sappers and Miners.*

The galleries † (A, B, C,) were executed by day-work, and advanced at an average 8 feet per day in a made ground of clayey soil, mixed with fragments of rock, of considerable compactness.

On completion of these galleries, the company was told off into 3 brigades of 1 serjeant, 3 corporals, and 9 privates, to relieve each other every six hours; the remainder employed in making hoses, casing tubes, &c. The work of forming branches and chambers 370 feet (total length) was equally divided among the three squads. As soon as the coffers were properly fixed and filled, and the train laid, each squad commenced a fresh branch, and the excavation was employed in tamping the one just completed.

The whole operation took a week.

A charge of 70 lbs. (13 inches cube) was let for its own depth into the counterforts at their junction with the escarp, with L L R = 9 feet nearly; and a charge of 50 lbs. (12 inches cube) let into the back of the escarp, also for its own depth (equidistant from the counterfort charges), with L L R = 8 feet. Average height of scarp, 21 to 25 feet: sound rubble masonry.

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* Abridged from Captain Melhuish's Report, Corps Papers, vol. ii.

† Presumed from the scale of the drawing to be about $5' \times 3'$ in section.

Fig. 8.—Plan of the Mines in the Glacière Bastion, as destroyed by Colonel Durnford, R. E.

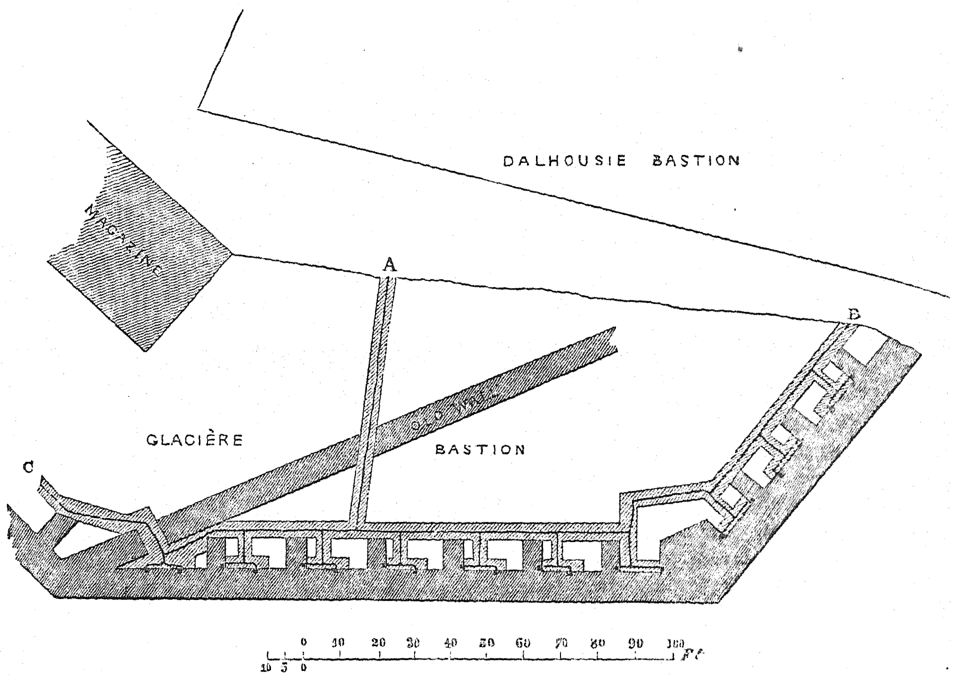
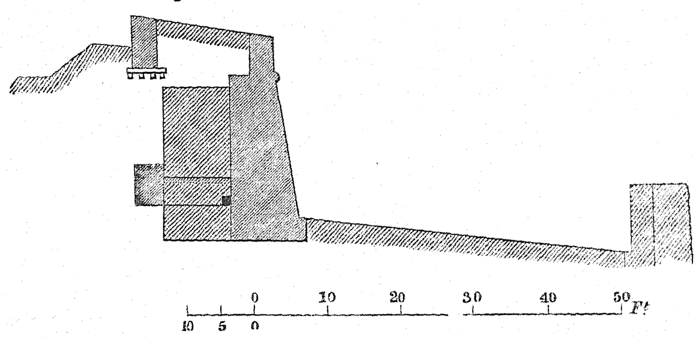


Fig. 9.—General Transverse Section of Fig. 8.



Accidentally, the whole twenty mines were exploded from A. The effect was perfectly satisfactory: the escarp crumbled to pieces, without a stone going 50 feet from its original position; and the whole parapet was brought down so as to form a thoroughly practicable breach.

The general line of explosion (ABC) was 220 feet long; the time of ignition along it did not exceed three seconds: hence it is to be presumed that a simultaneous explosion of mines, (requiring a great length of hose, much time to adjust, and

additional labour,) if resorted to, would not materially increase the effect.* The distance to which a gallery may be driven, without the aid of bellows, depends entirely on the state and temperature of the atmosphere. In the present instance, gallery A was driven at least 140 feet, and the lights burned tolerably well, though eight men were frequently employed in it. The above took place in the middle of February.

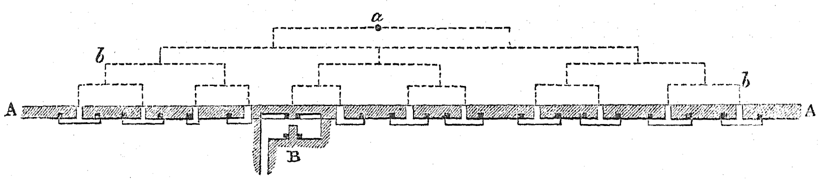
APPENDIX B.†

The galleries were driven through the escarp (A A), from face to back, with returns of 8 feet right and left. Chambers let fully into the back of the escarp.

	ft.	in.
Thickness of escarp at top	3	6
" " at base . . .	6	0
Height of escarp	20	0
Galleries from centre to centre . .	28	0
Chambers " " . . .	14	0

The galleries through the escarp were 4 feet high × 3 feet wide; the returns 3 feet high × $2\frac{1}{2}$ feet wide; all in solid rock, or remarkably tough masonry. In some of the galleries there were only 18 inches of masonry, and then rock to cut through. In others the earth was very loose; and in the rest, clay and thin layers of rock mixed.

Fig. 10.—Plan of the Mines at Fort Schulemburg.
a. Focus of ignition. *b.* Train.



In the two small casemates, (B), L L R = 14 feet, and each of the two charges there = 375 lbs.

In the escarp mines, L L R = 5 feet, the charge was 205 lbs.

Galleries commenced 2nd May. Loading and tamping, 29th May. Exploded, 10th June. One miner and two labourers per gallery; ditto per return.

The effect was most complete; the whole escarp with the 12 feet parapet being thrown down en glacis, particularly in front of the casemates.

In a recent communication to the Editors, Lieut.-Colonel Marshall observes, that the charges were decidedly too large, though the masonry was of the very best. The powder was of that left by the French in 1814; it was never used by our Artillery, but sold to the Greeks, or used in civil works: hence it would appear that the quality was deemed indifferent, and hence also, the apparent misproportion of the charges in the escarp chambers.

* The objection lies in the increased liability to accident to which long trains are subject.—*Ed.*

† Abridged from the Report of Major Marshall, R. E., Corps Papers, vol. ii.

For these escarp chambers $\dfrac{\overset{\text{lbs.}}{205}}{5^3 = 125} = 1{\cdot}64 \text{ L L R}^3.$

For the casemates considered as one mine $\dfrac{\overset{\text{lbs.}}{2 \times 375}}{14^3 = 2744} = \dfrac{750}{2744} = {\cdot}273 \text{ L L R}^3$, which is about $\frac{1}{6}$th of the above; but the position of these last was too irregular to admit of nice computation.

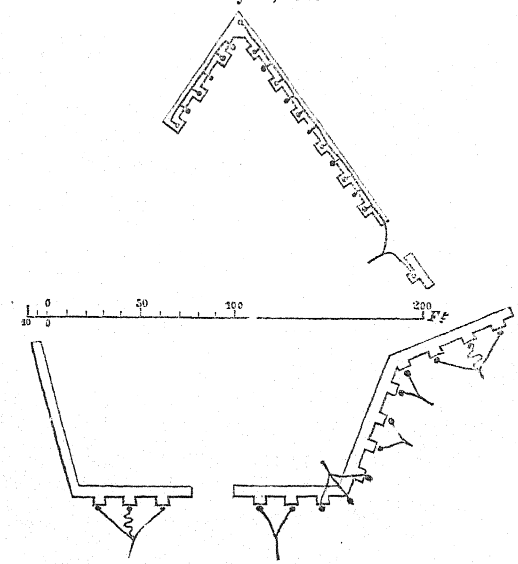
APPENDIX C.*

Report on the Demolition of the Revetments of some of the Old Works at Sheerness, on Saturday, July 14th, 1827.

GENERAL DESCRIPTION.

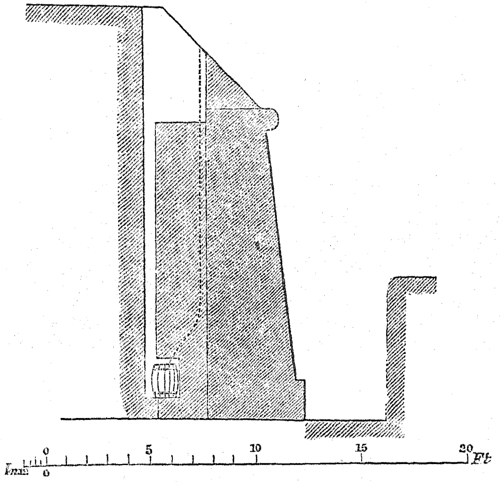
The revetments to be destroyed consisted of 266 feet in the face, flank, and curtain of a front of fortification in the old defences towards the land side, and of 260 feet of the revetment of the ravelin in front. The revetment in the body of the place was 16 feet 6 inches high, 3 feet thick at top, and 5 feet at bottom, supported by counterforts 3 feet wide, and 4 feet long, placed at unequal central distances of from 15 to 17 feet. The revetment of the ravelin was 10 feet high, 3 feet thick at top, and 4 feet 3 inches at bottom, supported by counterforts 3 feet wide by 2 feet 4 inches long, placed at regular central distances of 20 feet. Those works were originally surrounded by water, and at the time they were ordered to be destroyed were found to be covered up 6 feet from the foundation. The masonry was for the most part good, the bricks frequently breaking before the mortar; but from the settlement of the foundation several of the counterforts were cracked.

Fig. 11.—Plan of Revetments destroyed at Sheerness by Colonel Pasley, R. E., July 14, 1827.



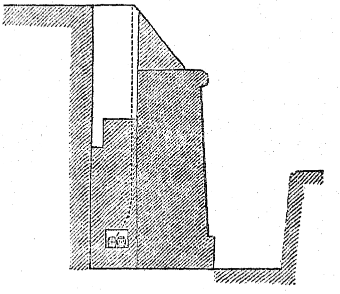
* Demolition of Revetments at Sheerness, by Colonel Pasley, R. E., from Corps Papers, vol. iii.

Fig. 12.—General Section through the Body of the Place, fig. 11.



Scale to figs. 5 and 6.

Fig. 13.—General Section through the Ravelin, fig. 11.



PROJECT OF DEMOLITION.

A trench was ordered to be cut along the face of the revetment of both works, 6 feet wide, and as deep as the foundations. In the body of the place, shafts were ordered to be sunk at the back of the revetment, by the side of each counterfort, and returns to be made into them 1 foot above the foundation, and at such a distance from the back of the revetment that the centre of the barrel which contained the charge should be in the centre of the counterfort, and 7 feet 6 inches from the face of the revetment.

In the ravelin, shafts were also ordered to be sunk at the back of the revetment, by the side of each counterfort, as well as one midway between each; returns were ordered to be made into the counterforts so as to lodge the charge in the centre, and 5 feet from the face of the revetment; the other charges were also laid 5 feet from the front.

The charges were calculated exactly according to Lieut.-Colonel Pasley's rules. In the body of the place, the lines of least resistance were taken 7 feet 6 inches; the calculated charge for which, for two-lined intervals ($\frac{1}{5}$th of its cube), is 84 lbs., but as some of the counterforts were more than 15 feet from centre to centre, a barrel or 90 lbs. was used. In the ravelin, the mines were exactly 10 feet asunder; the line of least resistance was 5 feet, the charge for which was exactly 25 lbs., being also $\frac{1}{5}$th of its cube.

In the large mines, the barrel was lowered down and placed on its end in the return, the copper hoops having been previously taken off, and a hole drilled in the top to receive the hose: the top was off at this period. That part of one of the staves nearest the hole, which projects above the top, was knocked off to prevent the hose from being cut whilst laying it; the hose was pushed into the barrel about 9 inches.

In the smaller mines, large bags were used, and the hose sewn into them; and where there was any symptom of moisture, laid in straw.

Three-quarter-inch hose was used, but it was thought that half-inch would have been quite sufficient.

The mines in the ravelin were fired in succession, first along one face, and then the other. For this purpose the hose was laid straight along the top of the revetment, communicating in succession with the short pieces coming from the charges, and fired from one extremity. In the body of the place, the mines were fired by twos or threes, for simultaneous explosions.

EFFECT.

The most complete demolition was produced. The whole revetment, from one extremity to the other, was laid in ruins, and yet so nicely were the charges calculated, not a brick was thrown 50 yards, and people at that distance might have looked on in security.

It was observed that the mines in the body of the place produced a greater effect on the ground to the rear than might have been anticipated: the shock on the adjacent mines prepared for explosion was such as to lay the hose, which was previously covered with 3 or 4 inches of earth, quite bare.

In firing the mines, commencing at No. 1 in the left face of the ravelin, Nos. 1 and 2 failed. This was owing to the hose which was laid along the top of the revetment having been displaced by people getting over the work at this corner. Had the precaution of taking a half-hitch with the hose coming from the mine, around that which ran along the revetment, been taken, this accident would not have occurred.

In firing the mines in the right face, commencing between Nos. 18 and 19, Nos. 19 and 6, at the two extremities, failed; the hose in this case burnt to the edge of the shaft, and there stopped. I attribute this to the hose being choked at the angle, and the powder settling down a little in the shaft, so as to cut off the communication.

In the body of the place we commenced with Nos. 1, 2, and 3, simultaneously; then 4 and 5; then 6, 7, and 8; then 9 and 10; then 11 and 12; and then 13, 14, and 15. All these succeeded, but the shock from Nos. 11 and 12 deranged the hose of No. 13 so much that Lieut.-Colonel Pasley ordered it to be cut: after Nos. 14 and 15 were fired, the hose of No. 13 was completely buried, but we succeeded in finding it by digging, and fired it also; but owing to the quantity of rubbish that had closed in around it from the right and left, its line of least resistance was changed, and became vertical; the crater produced was very large.

HENRY JAMES,*
2nd Lieut., Royal Engineers.

APPENDIX D.†

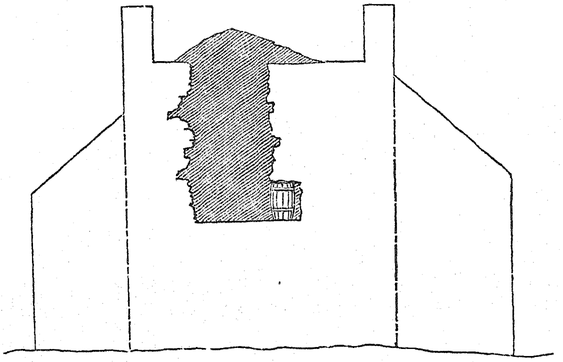
Banagher Bridge.

Of rubble masonry of a very inferior description, and consisting of seventeen semicircular arches.—Moderate but complete demolition was desirable. The piers varied from 14′ 6″ to 17′ in thickness: mean thickness 15′ 9″: hence $LLR = 7'\cdot87$. Major-General Pasley's rule of $\frac{LLR^3}{10}$ or $\frac{487,443}{10}$ = about 50 lbs., was tried, in *alternate* piers: the shafts were sunk 8 feet deep, a little on one side of the

* Now Capt. James.

† Abridged from Corps Papers, vol. viii. No. 1, by Lieut.-Colonel H. D. Jones, R. E.

Fig. 14.



mid-width of the bridge, so that the charge (lodged in one face of the shaft, and at the bottom) might be exactly in the centre of the pier and roadway: the tamping consisted of the excavated materials replaced. Bickford's fuze was used to ignite the charge; * and one man was told off to fire each shaft: the whole were lit at once by signal. "The explosions were nearly simultaneous; the entire bridge appeared to be raised a few feet, and then fell in a confused mass of stones, with the exception of a small portion of two piers, which remained standing: no stones were thrown to any distance, and the demolition might be considered perfect. The patent fuze answered admirably, as it has in all cases where it has been employed on the Shannon, and at other places where I have had opportunities of using it."

Rooskey Bridge.

Consisting of good external rubble facing, generally speaking filled (in both piers and spandrils) with loose earth and stones,—except where two parallel walls, about 18 inches thick, and 3 or 4 feet on each side of the centre, ran like partitions along the whole length of the bridge, crossing the spandrils, and passing down into the piers. One large arch in the centre, and four smaller ones on each side. The six piers of the seven central arches were from 6 to 7 feet thick; the two piers nearest the abutments were 20 feet thick.

As it was necessary to avoid ruining the temporary wooden bridge running close alongside of it, very moderate charges were advisable; hence, experimentally, $\frac{LLR^3}{32}$ was tried at first in one of the 20-feet piers, and one of the small piers, but unsuccessfully. $\frac{LLR^3}{20}$ was then tried for both the large piers, and a much higher proportion $=\frac{LLR^3}{2{\cdot}75}$ for the small ones. The result was only partially successful in the latter; but by re-loading those that had suffered least with $\frac{LLR^3}{1{\cdot}318}$, the remainder were all brought drown, excepting half an arch, which fell next day. This example is valuable, as giving a limit beyond which success cannot be expected. The bridge was an indifferent structure, and the charges the lowest possible.

The voltaic apparatus was used in this last instance, with, as usual, complete success as far as instantaneous ignition was concerned.

The powder used in the preceding cases was from private mills; strength $=\frac{19{\cdot}5}{21}$ of Government L. G.

* The Civil Engineer, apprehensive of failure, put two fuzes, but the precaution was unnecessary.

APPENDIX E.—Including Table VI.

General notices for Demolition, in reference to—

A. The position of the charge—
B. The mode of reaching the point where it is to lie—
C. The amount and size of the charge itself—

With regard to—

1. Revetments not exceeding Vauban's ordinary profile.
2. Revetments exceeding Vauban's ordinary profile, or in very massive pier-walls.
3. Towers.
4. Cisterns.
5. Military buildings.
6. Bridges.
7. Barrier gates and town gates.
8. Booms.

A.

A. With time. A 1. Vide fig. 1.
A 2. Vide fig. 2.
A 3. Vide fig. 6.
A 4, 5. In the heart of the walls, and particularly at the angles: or else, cut the lower part of the wall into piers, and deposit the charges in them.
A 6. In the piers; generally in two charges along the axis of the piers.
A 7. Powder-bags, hung up at the centre.
A 8. Powder-cases, merely pushed under.

A′. Against time. For all—adopt the most expeditious plan.
A′ 1. A′ 2. } In these, regulate the decision by hardness of escarp.
— hardness of backing.
— total work in gallery, or
— total work in shafts.
— quantity and quality of labour available.
— quantity and quality of stores.

A′ 3, 4, 5, 7. Powder merely in bags, boxes, or barrels, in a heap within, with such tamping as the case admits of. Figs. 4, 5, 7.
A′ 6. The powder sunk as deep on the crown of the arch as time permits, and loaded with what materials may be at hand.
A′ 8. As before.

B.

B. With time. B 1, 2, 6. By shafts. Figs. 11, 12, 13; or
By galleries from the front, *e. g.* Figs. 1, 2, 10; or
By galleries along the rear. Figs. 3, 8.
B 3, 4, 5. The short gallery. Fig. 6.

Mem. B 1, 2, 6, generally become a question of economy in labour and stores; but should there be any deficiency in skill, or in such stores as mining frames, &c., the simplest plan is the shaft, if the material is firm enough to stand unsupported.

B′. Against time. B′ 1, 2, 6. The shaft. Figs. 11, 12, 13.
B′ 3, 4, 5. The short gallery. Fig. 6.

C. (Vide Table VI.)

C. With time. C 1, 2. (On two-lined intervals) $\frac{1}{5}$ L L R^3.
C 3, 4, 5, 6. $\frac{1}{10}$ to $\frac{1}{5}$ L L R^3.

C′. Against time. C′ 1, 2. (On two-lined intervals) $\frac{2}{5}$ L L R^3 and upwards.
C′ 3, 4, 5.—$\frac{1}{2}$ L L R^3 and upwards.
C′ 6. 300 lbs.—1000 lbs.
C′ 7. 75 lbs.—300 lbs.
C′ 8. 56 lbs.—112 lbs.

TABLE VI.

Abstract of preceding instances of Demolition.

Place.	Nature of work.	Material mined in.	Location of mines.	Average distance of charges apart in L L R.	Charge in lbs.	L L R feet.	Ratio of charge in lbs. to L L R 3 in feet.	Remarks.
Turin A	Bastion escarp.	Best masonry.	Rear of escarp, and *in* counterforts.	1·5	97	7·0	·282	Demolition complete. Foreign powder.
Flushing B	Piers of lock-gates.	Brick.	*In* the pier.	3·55	270	9·0	·37	Do. British (Government) powder.
Quebec C	Bastion escarp.	Good rubble masonry.	Rear of escarp, and *in* counterforts.	1·3	70 50	9·0 8·0	·096 ·097	Do. Do.
Corfu D E	Escarp. Casemate.	Rock and masonry. Masonry.	Rear of escarp. At end of the casemate each side of pier.	3 ×	205 750*	5·0 14·0	1·64 ·273	Do. Admitted to have been excessive. Foreign powder.
Sheerness F	Bastion escarp. Ravelin escarp.	Good brick-work.	Rear of counterforts. Rear of escarp, and centre of counterforts.	2 2	84 25	7·5 5·0	·2 ·2	Do. Calculated on Major-General Pasley's Rules. Government powder.
Banagher G	Bridge.	Very inferior rubble.	Piers.	×	50	7·87	·102	Do. Do. do. Merchant powder.
Shannon† H	Bridges generally.	Average masonry.	Piers.	,,	,,	L L R 3	·33	Do. Merchant powder.
Verona I	Tower.	Brick or masonry.	Heart of the wall.	×	50	3·75	·95	Do. Foreign powder.

Deductions from the above as to Escarps,—i. e. from A *to* F.

Taking into account the use of foreign powder, and other circumstances, B, C, and F, are the only cases that can be fairly compared. Of these, F, as established by Major-General Pasley, affords the best basis; and taking the distances of the charges apart into account, it is very reasonably supported by B and C, and somewhat more approximately by A and E. B seems to be the most advisable in cases of doubt or expedition.

Considering what immense powers and unwieldy masses are generally opposed to each other in demolitions, and the rude results that, after all, are to be obtained, there is no ground for expecting a *very* close coincidence in these cases.

* The two charges of 375 lbs. were very close together.

† Excepting Rooskey, which was too peculiar for comparison.

DEMOLITION OF ARTILLERY.

COMPLETE DEMOLITION.

*Iron Guns.**—"The mode that I have generally adopted, is to half fill the gun with powder, and jam in one or two shot with stones, bits of iron, &c.; over this a complete tamping with stones and a little earth, till the bore is filled. I have seen this done with more than a hundred guns, and never knew it to fail.† To break off the trunnions is by no means an infallible mode of destroying ordnance: the French, in 1807, near Tarentum, had the guns of a battery thus imperfectly demolished in action, in half an hour after a work was recovered: they were probably fired on the ground. The place of the trunnion has also been temporarily supplied, in the British Navy, by passing a chain round the carriage (vertically) and slinging the gun in the bight, the breech of course resting on the quoins. The difficulty in laying a gun accurately when thus deprived of trunnions is very effectually met by laying a long triangular batten along the line of sight for the time being,—the vertex of the batten on the base ring, and the other end or base on the muzzle-mouldings,—this base being equal to the difference of the radii of the gun at those two points, so as to render the gun for the moment a cylindrical piece, and do away with dispart. The upper edge of this batten should have a groove along it, and be painted white. When time admits of only crippling guns partially by removing the trunnion, this is best done by laying its end on a block of wood, the blow being given by a sledge-hammer, or (if that be not at hand) by heavy shot; but the hammer is preferable as being more under control."

A shot may be fired at the gun behind the trunnions, which, if it should not break it, would render it unsafe. When old ordnance is sold, it is usual to break off one or both of the trunnions, to prevent their becoming an article of trade, except as old metal.‡

Brass Guns.—A shot is fired into them from some other piece, behind the trunnions, which will prevent the possibility of their being used again.‡

At Madrid, on finally evacuating it, the French destroyed their brass battering guns by keeping them over large fires till they 'drooped;' though, when well heated, a few smart blows from a sledge-hammer will render such guns useless.

TEMPORARY DISABLEMENT.

The spring-spike is used in rendering one's own guns for a very short time useless to the enemy,—as when guns are confidently expected to be quickly recaptured on the field. In this case, the gun would also, if possible, be dismounted; the rammer, &c., &c., would be taken away at all events.

The common spike would be used when the guns, on either side, are to be disabled as much as possible, though time does not admit of a more effective operation. This spike consists of a long tapering cone,—the larger end of steel, and the rest of soft iron, so as to bend back when driven well down on the lower surface of the bore.

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* For the first paragraph we are indebted to the verbal communications of Captain Sir Thomas Herbert, R. N.

† The doubt existed in consequence of a failure during the late war in destroying some French 36-prs. in a battery on the coast of Calabria. It has been suggested by an Artillery Officer, that partly burying the muzzle of an iron gun would be an assistance, if any doubt existed as to the efficacy of the processes now detailed.

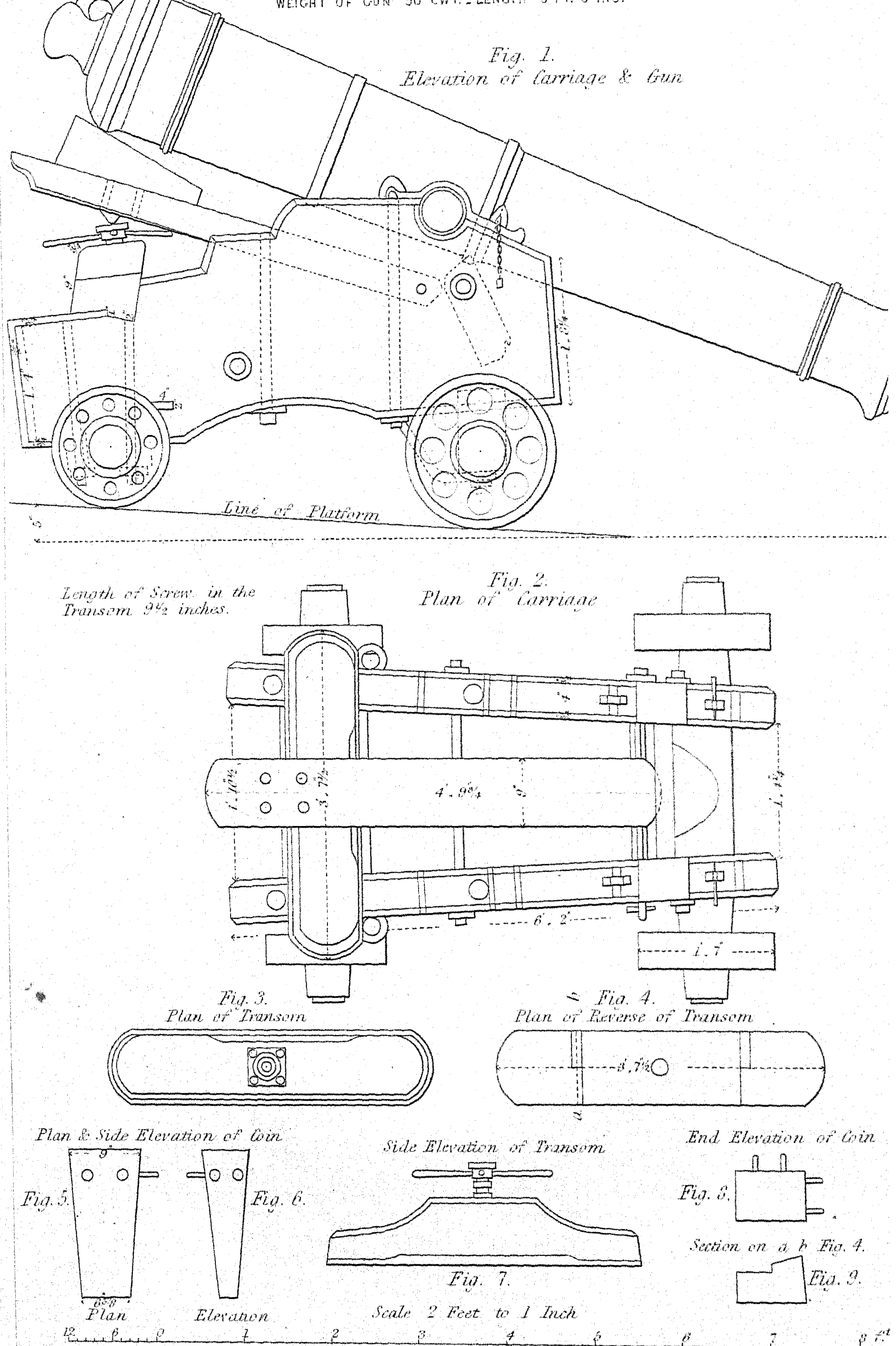
‡ Paragraphs from Notices by Lieut.-Colonel Dundas, C.B., R.A.

PLAN AND ELEVATION OF A

DEPRESSION CARRIAGE FOR A 24 PR IRON GUN

IN ST GEORGES HALL, GIBRALTAR.

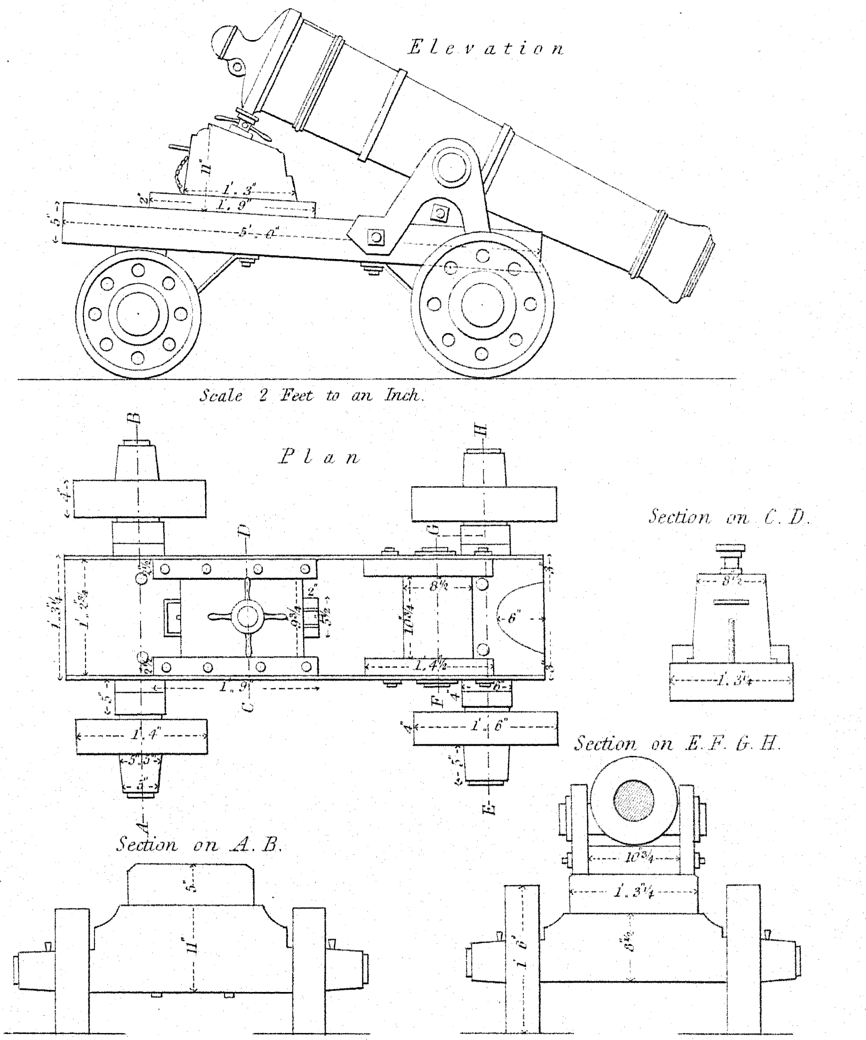
WEIGHT OF GUN 50 CWT. _ LENGTH 9 FT. 6 INS.



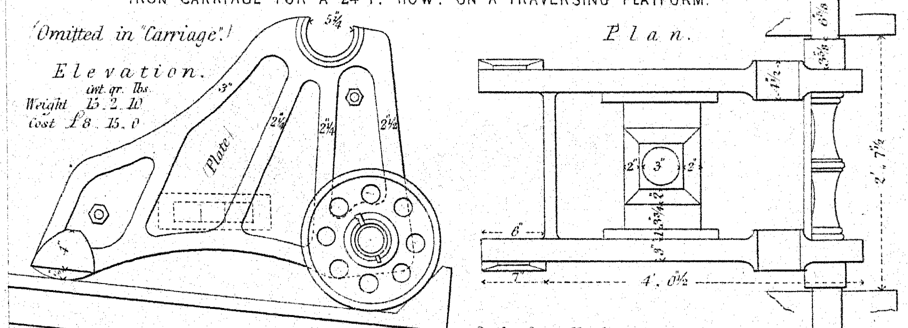
PLAN, ELEVATION AND SECTIONS OF A

DEPRESSION CARRIAGE FOR A LIGHT BRASS 12 PR GUN.

LENGTH 5 FEET, CALIBRE 4·62 INCHES, WEIGHT 12 CWT. 0 QRS. 3 LBS.



IRON CARRIAGE FOR A 24 PR HOWR ON A TRAVERSING PLATFORM.



Scale for all the above figures

5

CARRIAGE FOR A PRUSSIAN 12 P^{R} GIVING 40^{+} DEPRESSION.

a Pin attached to B and sliding along a groove e (Fig. 2) in A so that the Gun may be turned round for loading on the bolt s being drawn.
b Moveable transom with elevating screw dropped into the notches f f
c Spring catch to retain B when recoiled.
d Supports for the man laying the Gun to stand on
g Iron bar

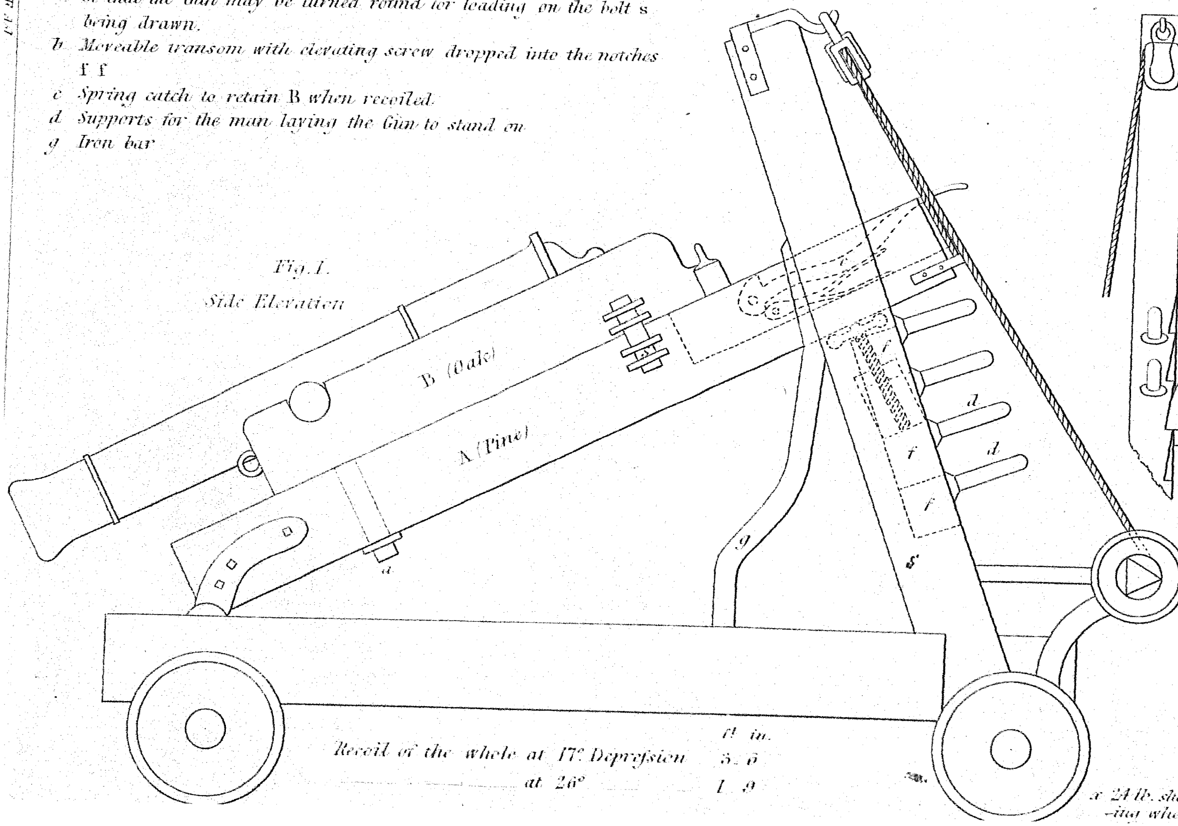


Fig. 1.
Side Elevation

	ft	in.
Recoil of the whole at 17° Depression	5	6
at 26°	1	9

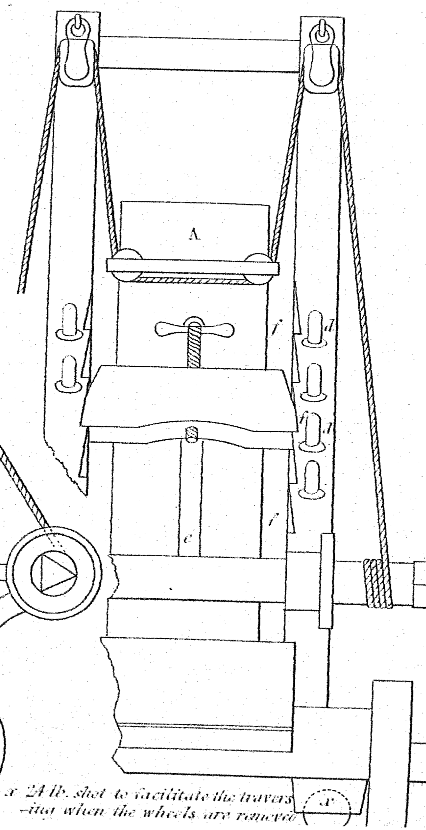


Fig. 2.
Rear Elevation

x 24 lb. shot to facilitate the travers-ing when the wheels are removed

P. Bainbrigge Lt R.E. del

Nails without heads (like flooring brads) are good substitutes for these; and it has been suggested by the Author of the Introductory Paper to this work, that every Troop-farrier of Cavalry Regiments should be supplied with one or other of these last, and a hammer to disable the enemy's guns in the few minutes for which a charge, with only temporary success, may obtain possession of them. According to this Officer, this has been a singular point of improvidence in the British Service.

It would be desirable that the spike, punch, and hammer formed part of the equipment of the Pioneer. R. J. N.

DEPRESSION CARRIAGES.*

There is a general resemblance only between these and the common standing garrison carriage:—for the points of difference, compare them with figs. 6 to 9, 'Carriage,' Plate I. They admit of a depression of 30°, but after every round the piece must be brought to a horizontal position to be loaded, which is done by taking out the rear transom altogether.

Note.—The 24-pounder iron howitzer having been unintentionally omitted in Artillery Tables G. H., the following is given to correspond with the figures of the Iron Garrison Carriage for this piece, inserted in Plate II. of 'Depression Carriage.'

Elevation, Depression, and Height of an Iron 24-pounder Howitzer mounted on an Iron or Wood Carriage upon an Iron Traversing Platform, viz.

<table>
<tr><th rowspan="2"></th><th>Elevation.</th><th>Depression.</th><th colspan="2">Height.</th></tr>
<tr><th>With elevating screw.</th><th>With elevating screw.</th><th>From platform to axis of howitzer.</th><th>Under swell of muzzle at 5° depression above the platform where the trucks stand.</th></tr>
<tr><td></td><td>°</td><td>°</td><td>ft. in.</td><td>ft. in.</td></tr>
<tr><td>Iron 24-pr. howitz. mounted on an iron carriage</td><td>16</td><td>5</td><td>2 9</td><td>2 $2\frac{5}{8}$</td></tr>
<tr><td>Iron 24-pr. howitz. mounted on a wood carriage</td><td>$17\frac{1}{2}$</td><td>5</td><td>2 8</td><td>2 $1\frac{5}{8}$</td></tr>
<tr><td colspan="3"></td><td>Value.</td><td>Weight.</td></tr>
<tr><td colspan="3"></td><td>£. s. d.</td><td>cwt. qrs. lbs.</td></tr>
<tr><td colspan="3">Carriages for 24-pounder iron howitzer: iron carriage . . . . .</td><td>8 15 3</td><td>15 2 10</td></tr>
<tr><td colspan="3">Carriages for 24-pounder iron howitzer: wood carriage . . . . .</td><td>10 4 5</td><td></td></tr>
</table>

DERRICK (SHEERS, &c.)

The Derrick, Sheers, and Gyn have one object in common,—to find a point or fulcrum in space, to which the pulley, in the shape of block and tacle, is to be applied; and this is effected by the above, on one, two, and three legs, respectively.

In the derrick, and sheers, stability is given by guys; in the gyn they are unnecessary. Wherever these guys are used, great attention must be paid to their being

* Unavoidably delayed, or would have been given under 'Carriage,' as noticed, p. 207.

well fixed, or being (when requisite) duly eased off: when accidents do occur from neglect in this respect, they are generally *very* severe.

The applications of Derrick and Sheers about to be given are likely to provide for every probable occurrence, as the most extreme cases have been expressly selected; and these will be generally found in the practice of the Navy.

DERRICK.

An unusually bold application of this was made* with perfect success in building the block-house at the confluence of the Madawaska and St. John's, New Brunswick, in 1841. Figs. 1, 2, 3, 4, 5, Plate I., explain the operation, one peculiar advantage of which lay in the ease with which the whole apparatus was shifted from side to side of the building as required, and in the rapidity with which the work proceeded; for although the workmen (colonial) were so unpractised that they at first raised and placed only two logs (each 35 feet × 13 inches × 13 inches, weighing about $1\frac{1}{4}$ ton) per day, yet the walls of the second and third story, each 11 feet high, were completely raised and framed by ten Canadian peasants in about a month; the last twelve pieces having been fixed in one day. Not a single accident occurred.

Defe

It is to be observed, that from the height of the building and its inconvenient position, and as the baulks (held on by the hand-guys *dd*) were not allowed to swing to the rear, no front guys were used. The baulks were landed at first on the two ends of the loose planks (*ff*), and afterwards turned over into their places by cant-hooks.

Plate I.

Figs. 1, 2. B. Baulk just raised, slung to the tacle by common dog-chains.
a a. Double blocks.
b. Derrick.
c′ c c. Guys with a loop at the end, to be quickly thrown on, or taken off from, the head of *b*.
Mem: *c′* is stronger than *c c*.
d d. Small hand-guys for guiding the block.
e. Leading block.
ff. Two 3″ planks to land the baulks; their own weight kept them steady.
g. Spars to prevent the timber from chafing.

Fig. 3. *a.* A round spruce-wood pole.
b b b. Iron hoops.
c. Of $1\frac{1}{2}''$ round iron, with linch-pin and washer; the wood being well guarded with iron at each mouth of the hole where *c* passes through.

Fig. 4. A baulk slung in dog-chains.

Fig. 5. A cant-hook: the lever (A) may be about 5 feet long.

GETTING IN THE BOWSPRIT BY THE FORE-YARD.†

(Here the derrick is made by lowering and slinging the fore-yard obliquely to the fore-mast.)

Plate II.

"When a new bowsprit is to be stepped, it is generally (in the Merchant Service) got in without sheers, by the fore-yard (fig. 1); the slings being cast off.

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* This application was made by Lieut. Simmons, R. E.

† From Darcy Lever's 'Young Sea Officer's Sheet Anchor,' p. 70.

"The fore-yard is lowered down one-third (or any other distance, according to its squareness), by the jears, if they be carried; or otherwise by tacles from the lower cap. The single block of the starboard-yard tacle is brought to the cat-head (*g*), hooked to a pair of slings, and the fall taken through a leading block (*h*). By bowsing on that tacle, and gathering in the larboard lift (*i*), the yard is got fore and aft within the rigging; and if the bowsprit be stepped between decks, it will require to be carried very forward, and the yard-arm may be lowered or topped by the lift as occasion requires. A strong lashing is passed round the mast at *k*, and a large single block at *l*. A hawser (*m*) is reeved through the top block (*n*), (or through a block lashed to the fore-mast head above the rigging) through the block (*l*), and the end is hitched round the fore-mast. The other end of the hawser is hove taut and belayed, which secures the yard against the strain of the purchase. The purchase-block (*o*) is lashed round the yard, and the lower block (*p*) is toggled to a stout selvagee on the bowsprit. A back rope or guy (*q*) is reeved through a block lashed round the fore-cap, and hitched round the bowsprit end, which guys it in the direction required, whether it be more horizontal or perpendicular."

In the Engineer Department, the probable application of the derrick, or the sheers, as given in Plate II., would be in setting up large flag-staffs, signal-posts, telegraphs, &c. It is however a powerful resource for the Service generally.

TO GET IN A NEW MAST BY THE OLD ONE, WITHOUT SHEERS.*

Fig. 2.

"If a vessel have a damaged mast, and be so circumstanced that she cannot procure spars of sufficient dimensions to hoist in a new one by,—strip all the rigging, except the runner pendents (*n*) off the damaged mast. Take the runners and tacles to the chains, setting them taut, two fore and aft guys (*m*) to the mast head, and also a girt-line block (*k*). Secure the mast above the partners with fore and aft tacles (*p*) and heel-ropes from side to side (*s*). Lash the purchase-block (*o*) to the mast head. Whilst this is doing, let the deck be well shored below. When all is secured, saw the old mast off close to the deck, wedging it as it is sawn; and being cut through, move it aft by the guys and heel-ropes as before. Drive a large bolt into the head of the stump (*q*) remaining in the hold; and, the lower purchase-block (*r*) being lashed to it, hoist it out. The new mast is then got in by the purchase, as before; and when stepped, the upper purchase-block (*o*) may be shifted to the new mast head, the lower one toggled to the selvagee on the old mast, and the runners, guys, &c., being cast off, the old mast may be hoisted out by the new one."

SHEERS.

Used for lifting and manœuvring a class of subjects too unwieldly for the derrick, and requiring greater control in management that it can afford. Amongst the severest practices are the lifting masts into ships in different ways: any probable Engineer operations of this description would be trifles compared to them.

Particular attention should be paid to the mode of moving sheers from place to place without taking them down, by means of the guys and heel-ropes.

GETTING IN LOWER MASTS AND BOWSPRIT.

1. *Setting up the Sheers.*

Plate II. fig. 3.

"Sheers† for getting in the lower masts and bowsprit‡ are made of two large

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* From Darcy Lever, p. 19. † From Darcy Lever, pp. 17, 18.

‡ In Dockyards this is done by either standing-sheers on the wharf, as at Woolwich, or by a sheer-hulk, as at Devonport. The above and following are resources on emergency abroad.

spars: a strong lashing secures them by their heads (a). Over the head of the sheers, at the lashing, a large three or fourfold block (b), according to the size of the largest mast to be got in, is secured, connecting itself by a fall to another block (c). At the head of the sheers are four ropes, called *guys*, two leading forwards, and two aft (d). Also at the upper end of one spar, a girt-line block (e) is made fast, and its line reeved through it: this is to hoist up a man in case of emergency. At each heel of the sheers there is a tail tacle (f) leading aft, and two others (g) are overhauled forwards.

"Previously to the sheers being raised, two planks (1, 2), long enough to lie over three beams, (which are shored below,) are placed upon deck on each side, for their heels to rest on.

Fig. 4. "The lashing of the sheers is passed like a throat-seizing, not too taut; and then the heels of the sheers are drawn asunder: they are laid over the taffarel (h, fig. 4); and (if the ship do not carry a poop) to make them rise easier, a spar (i) is laid athwart, over the fife-rails. The lower purchase-block is then taken forwards, the fall (k) being overhauled, to the breast-hook, or the ring-bolt in the stem, for the main-stay. The fall being taken through a leading block, is brought to the capstan, and hove upon. The cross spar (i) cants the sheers, and their heels are prevented from flying forwards by the tail-tacles.

"When the sheers are up, they are moved forwards or aft, by the guys and heel-ropes.

"The guys are hauled taut, and the block cast off from the breast-hook."

2. *Getting in the Mast, &c.*

Fig. 5. "The mizen-mast is first got in; for which purpose the sheers are placed before the partners or hole (d), which the mast is to enter; and the lower purchase-block is lashed on a little above the centre of gravity of the mast, that it may have a cant upwards. But in preference to this lashing, a stout selvagee, made of spun-yarn, should be taken round the mast (a), the bight put through the strap of the lower purchase-block, and a toggle clapped in. This, from its pliability, will be sure to hold, and is quickly done.

"Two girt-line blocks, one on each side of the mast-head (b), are lashed, to be ready to get the rigging overhead, and to hoist men on the trestle-trees, in order to place it properly. The end of the girt-line, which was made fast to one of the sheer-heads (c), is taken round the mast under the bibbs. This is called a *back-rope*.

"When the mast is high enough, this *back-rope* is hauled upon, which places it in a vertical direction over the partners or hole (d). Some hands on deck also assist at the heel of the mast, to make it enter. The purchase fall is then eased, and when fairly entered, they lower away; the people in the hold placing the tenon (e) in the heel, into a mortise of a large piece of oak timber, called a *step*, which is bolted on the upper part of the kelson.

"When the mizen-mast is fixed, the sheers are moved forward by the guys and heel-ropes, as seen in fig. 2, and placed before the partners of the main-mast. This and the *fore-mast* are got in, and stepped, in the same manner."

GYN.

Applicable when the weight to be raised is to have little or no lateral motion, as in the Artillery Gyn, Plate III. The 'cheeks' (or front legs) of this, together with the windlass, can also be used as sheers, especially in getting up ordnance on towers, &c., where the parapet is thick enough to allow the gun to rest well upon it when

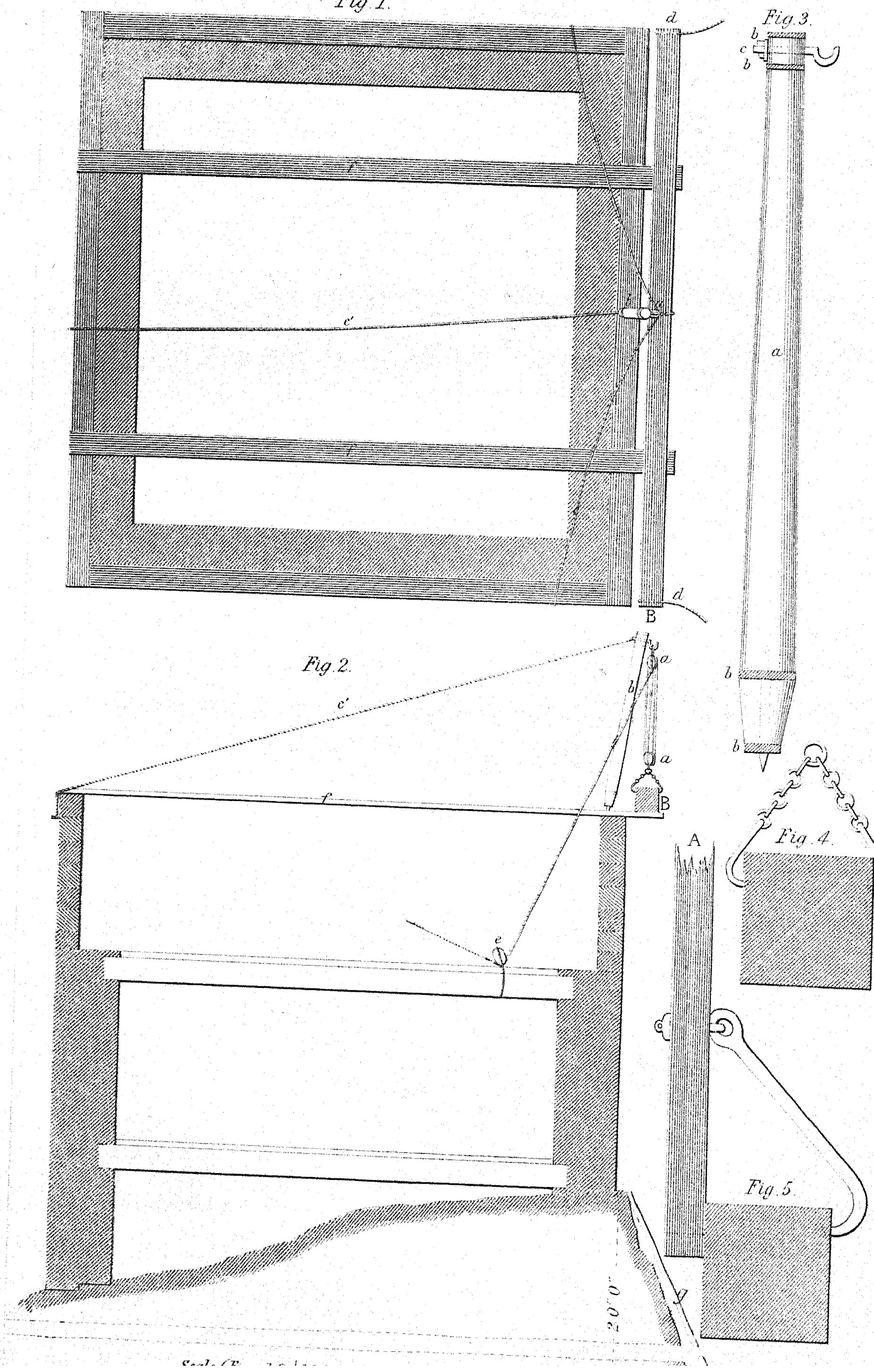


Fig. 1.
d
c'
f
f
d
B
Fig. 2.
c'
a
b
a
B
f
e
20' 0"
g
Fig. 3.
b
c
b
a
b
b
Fig. 4.
A
Fig. 5.

Defe

Fig. 4.

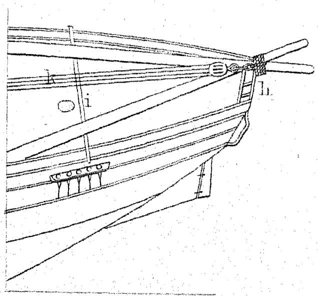


Fig. 3.

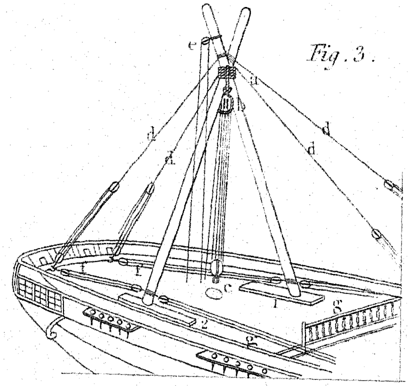


Fig. 2.

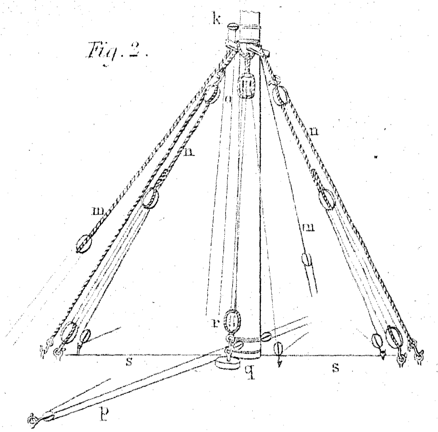
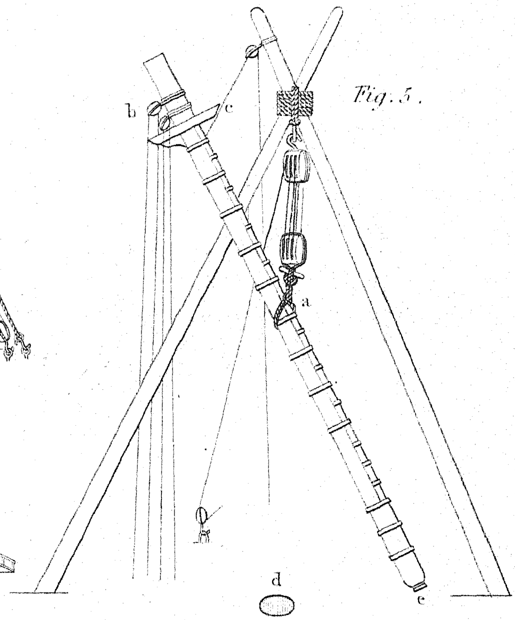


Fig. 5.



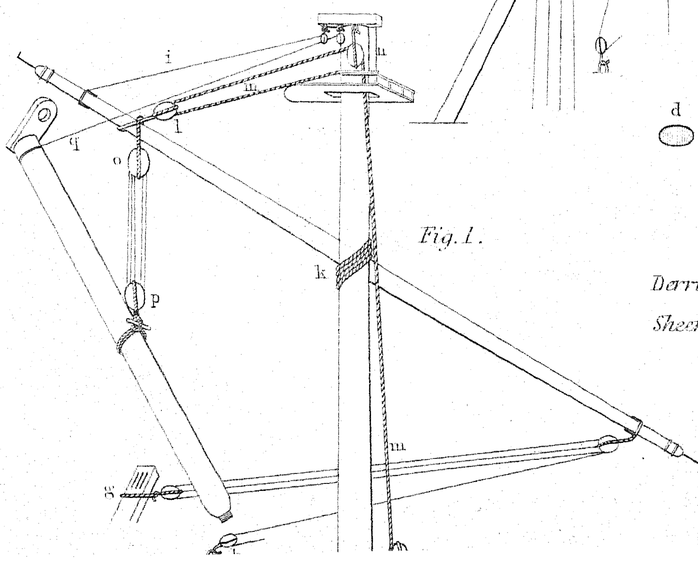


Fig. 1.

Derrick ...... Figs. 1 2

Sheers ...... Figs. 3 4 5

cfe

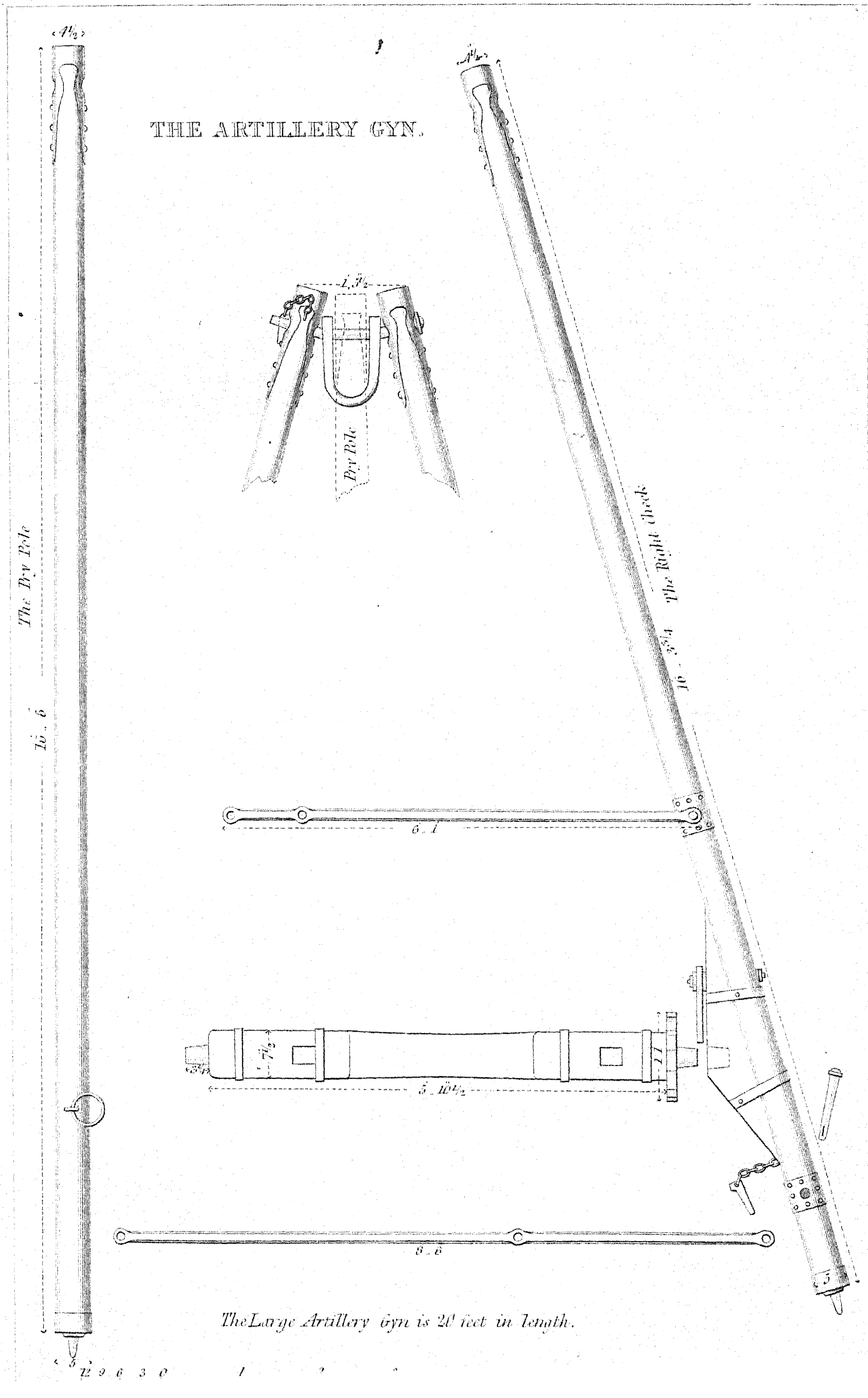

THE ARTILLERY GYN.
4½
The Pry Pole
15 . 6
1 . 3½
Pry Pole
4½
The Right Cheek
16 . 3¾
6 . 1
7½
11
3¼
5 . 10½
8 . 6
5
The Large Artillery Gyn is 20 feet in length.
12 9 6 3 0 1 2 3

Fig.

first brought in over the exterior crest, as in most cases the sheers must be set up afresh before they can be used for mounting the gun, or removing it to the interior of the work. The pry-pole is equally available as a derrick, particularly such as shewn in Plate I. Hence the singular value of this engine when well fitted and finished, as combining in itself the capabilities of derrick, sheers, and gyn.

In the Engineer Department, this is seldom used, except in such very temporary arrangements for sawing timber as either do not admit of sinking a regular saw-pit, or where the logs lie so widely scattered, that it is easier to bring the saw to them than them to the saw. The timber is hauled up between two rough gyns, one at each end, high enough to allow play for the 'pit-sawyer' standing on the ground: it is steadied by lashings, or by resting on cross bars, which are removed as required, to allow the saw to pass. These gyns need only be of light spars, to suffice for very heavy baulk, and require no iron fitments, it being enough to lash the three pole-heads together.

R. J. N.

DETONATING POWDER.—*Vide* 'LABORATORY.'

DIALLING.

In all Dials, the Gnomon represents the Axis of the Earth: hence its angle (L. fig. 2, Plate) with the horizon is the latitude of the place, and it lies in the plane of the meridian.

The hour-lines are the projections of the horary meridians, given by the intersections of their planes with that of the horizon, or dial.

There is a great variety of dials, according to whether they are horizontal, oblique, or vertical, and also depending on their aspect with reference to the sun; but the above principle is common to all; and the Horizontal is the only one that will be here noticed, as being the simple form of which all the rest are only more or less curiously elaborate projections, and also as being by far the most generally useful, at outposts and other remote places, where there are seldom clocks, and where it is otherwise often difficult to obtain even a tolerable approximate to correct time. In Tables XVI. and XVII., Part III., the Sun's Declination and the Equation of Time are given with sufficient accuracy to afford independent means of determining the latitude, and of reducing the solar to mean time.*

The most convenient of the trigonometrical elements to receive the projections for the hour-lines, is the 'cosine' of the hour; therefore divide the circumference of the circle into 24 equal parts, $a b$, $b c$, $c d$, &c., for hours; join $a a'$, $b b'$, $c c'$, to obtain the so-called 'cosines;' and in fig. 2 reduce A a, B b, C c, &c., as sines of the angle L (latitude). Apply these sines to the 'cosines' A a, B b, C c (in fig. 1), as A 1, B 2,

* Should the necessary instruments not be at hand, the latitude in the northern hemisphere may be obtained with sufficient accuracy by the careful use of a Gunner's quadrant (or other like simple contrivance) from the elevation of the Pole star. In the southern hemisphere we have no such assistance, but the latitude of the place may be obtained from a *good* map. Under like circumstances as to instruments, the meridian can be laid down by 2 vertical rods, say 100 yards apart, lined on the Pole star; or by dressing one of them on the line given by the same star and some known object. In the southern hemisphere, the simplest mode is by bisecting the angles A a A, B b B, &c., given by equal shadows of an upright central wire (a, fig. 4) on the respective concentric circles A B C, &c., drawn on a white surface. In all these rude contrivances, the operations should be repeated many times, and the average of the *best results only* should be adopted.

C 3, &c.; then the radii from the centre F— F 1 I, F 2 II, F 3 III, &c., will be the required hour-lines. The like process must of course be followed for half and quarter hours.

T, fig. 1, is the thickness of the gnomon.

In southern latitudes, the P. M. hours will be on the left of the gnomon, those of A. M. on the right.

The angle L (fig. 2) of the gnomon would in fig. 1 be placed at F F′, which neither looks nor answers as well as when the gnomon has a more central position: to effect this the hour-circle is advanced, as shewn in fig. 3, though the divisions are only continuations of the original projection of the radii, as given on the dotted circle, (repeated for the sake of clearness,) as a copy of fig. 2.

A cylindrical pedestal and circular dial will be found more convenient for adjustment than those of a square or rectilineal form in plan; on these last, once built, the position of the dial-plate cannot be corrected without being set awry. The width of the gnomon, as given in figs. 2 and 3, is not in proportion; when made in copper or brass, it need not be thicker than F F′.

MEMORANDUM.

In reference to the second paragraph, if the eye is familiarized with the position of the hour-lines of the place as given on the sun-dial, the watch and pocket-compass, so long as the sun can be seen, may be substituted for each other when either may be wanting in a strange or an intricate country, in a forest, &c., as a guide to the general direction of one's route; premising that—

A. At 12 A. M. the Sun must be due South in the northern hemisphere, and North in the southern; at 6 A. M. and 6 P. M. he must be due East and West respectively, whether seen or not; and at 12 P. M., due North in the northern, and South in the southern hemisphere,—under which last circumstances, strictly speaking, he can only be seen within the frigid zones.

B. Also, that at either pole there will be no correction for the hour-lines, as given in fig. 2, as the axis is perpendicular to the horizon; and at the Equator, where the axis is horizontal, the hour-lines will be parallel to the also horizontal gnomon.

Time, from the Compass.

Ex. In latitude 60° N., as given in figs. 1, 2, 3.

The bearings (due) of	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
	XII.	XI.	X.	IX.	VIII.	VII.	VI.	V.	IV.	III.
will be, respectively	0°	13°	27°	41°	57°	73°	90°	107°	123°	139°

as nearly as may be apprehended by a common compass; the bearings for the upper line being due East,—for the lower line, due West. Hence, where there is no magnetic variation, these bearings of the Sun, by compass, would point out their respective hours. Suppose, however, that this variation is 10° E., the above will become—

XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
170°	3°	17°	31°	47°	63°	80°	97°	113°	129°

XII.	XI.	X.	IX.	VIII.	VII.	VI.	V.	IV.	III.
170°	23°	37°	51°	67°	83°	110°	117°	133°	149°

and these, once determined by projection (or else actually taken off by the compass from a sun-dial), and written (like the dial of a watch) inside the top of the compass case, will do nearly enough for a considerable range round the spot for which they were computed, considering the rudeness of the operation.

Fig. 1.

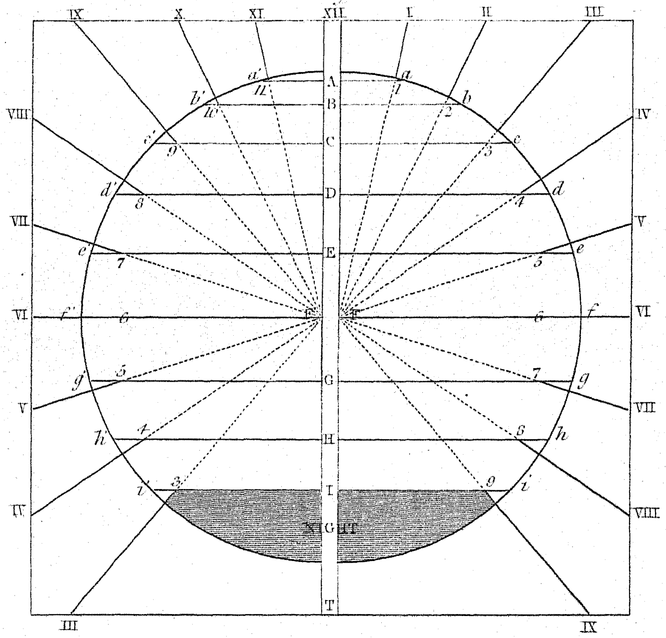


Fig. 2.

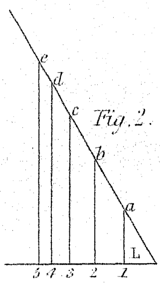


Fig. 5.

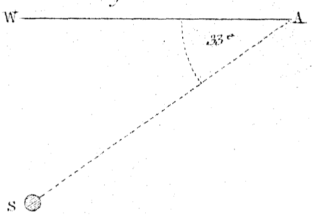


Fig. 3.

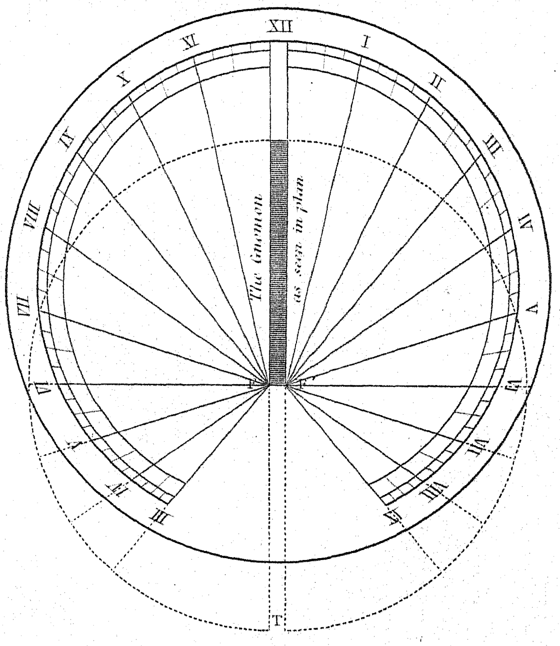
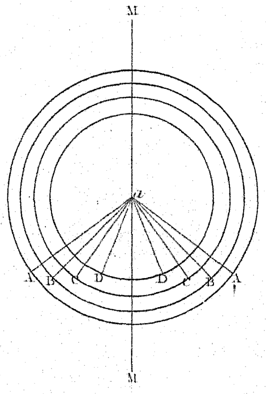


Fig. 4.



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Bearings, from the Watch.

Keeping paragraph A in mind, the problem is, given the hour and the direction of the Sun, to find the nearest Cardinal Point.

Ex. Suppose at 4 P.M. the direction of the Sun is A S, fig. 5; required the direction of the West?

At 4 P.M. the *due* bearing of F. IV. (fig. 1) is 57°; hence, looking towards the Sun, its bearing (or that of F′ IV.) is 33° (= $\angle$ IV. F′ VI.) from the West; and if this be laid off on A S by the eye, or at most by the help of two sticks, as A S, A W, the latter will point due West. R. J. N.

DISEMBARKATION AND EMBARKATION.

Operations necessarily a combination of the *sea and land forces*, under the control and superintendence of the former, and hence *disembarkation* and *embarkation* are services forming what is termed conjunct expeditions, on a small scale for predatory purposes, or on a large scale of operations for conquest or for transporting an army to the theatre of war in a foreign country.

In explaining the mode of executing the important duties of disembarkation and embarkation in detail, they are only noticed as combined operations of the two Services, land and sea. As regards naval operations alone, they will be omitted, having no reference to military subjects.

The Article will be divided into the following Sections:

1. Disembarkation and Embarkation of Field Artillery.
2. " " Siege Artillery and Stores.
3. Embarkation of Horses.
4. Disembarkation of Infantry.
5. Naval Arrangements for ditto.
6. General Orders and Instructions of the Officers commanding the Army in Egypt in 1801.
7. General Remarks.

SECTION I.

ON DISEMBARKING AND EMBARKING BATTERIES OF FIELD ARTILLERY.*

1. The disembarkation and embarkation of field artillery may take place under circumstances so various, that separate instructions for each mode of proceeding would be endless. The following directions are formed upon general principles, which will be found applicable to nearly all the cases which are likely to occur;—such as disembarking or embarking from a beach;—from a wharf;—with or without boats;—in presence of an enemy;—when all the carriages are to be in one ship, without horses;—when a portion of horses and carriages are to be in the same ship, &c., &c. Of course all arrangements of every kind must be subject to the control and authority of the General commanding.

2. The embarkation of the guns and carriages in boats should form part of the exercise to be taught to each company; and one or two boats should be fitted for the purpose of embarking and disembarking in the face of the enemy. The horses, of course, would not be embarked; but the battery should march to the place of embarkation complete in all respects; and it is under this supposition that the

* Taken from the Instructions and Regulations for Field Battery Exercises of the Royal Artillery.

following directions have been drawn up. Circumstances may render a departure from them necessary, but the general principles may always be adhered to, and the details will not be thought too minute, when the confined space of a ship is taken into consideration: how every thing must be heaped and crowded together, and how liable small articles are to be mislaid, and not available when they are wanted, which is of the same consequence at the time as if they were lost to the service.

3. Field batteries should always be embarked by the Officers and men belonging to them, who will then know where each article is stowed; and much time will, of course, be saved in their disembarkation, which is always more or less attended with hurry and confusion.

4. When a new battery is issued from store, the harness should be properly fitted to the horses; and all the articles of equipment properly fixed to the carriages; after which, every thing is to be re-packed in the vats and cases for their reception.

5. The embarkation on board all the ships should, as much as possible, be going on at the same time; but this must of course depend upon circumstances, and must be left to the discretion of the Commanding Officer. In some cases it may be practicable to embark the horses and the ammunition at the same moment; the latter down the after hatchway, and the horses down the main.

Embarking the Guns and Carriages.

6. Some previous notice should be given to the Commanding Officer, in order that he may make the necessary interior arrangements; he should be told the names, numbers, and tonnage of the transports allotted; whether horses and carriages are to be in the same ship; the number of horses each ship will contain; and whether the embarkation is to be from a wharf or beach.

7. If the battery is to be embarked immediately on its arrival, an Officer is to be sent forward to ascertain the precise spot for the embarkation; with the extent of wharf or beach which can be allowed for the battery, which should occupy as little ground as possible, if other troops or batteries are also to embark. Should the place not be the most eligible for the embarkation of the horses, which is the principal difficulty, he must endeavour to get it changed. He will ascertain the number of boats assigned, which should continue attached to the battery till the whole of it is embarked; and he will state the probable time of its arrival, that the boats may be in attendance. He will return and meet the battery, reporting the localities, facilities, &c., &c., for the embarkation. This is very essential, as any changes in the previous arrangements, which may become necessary in consequence of his report, may be more conveniently made before the battery arrives at the place of embarkation, where any unexpected alteration would add to the unavoidable hurry and confusion which generally attend such operations.

8. Two men are to be told off to each carriage, one of whom, for the gun, will be the non-commissioned officer in charge of the subdivision, and who is answerable for the proper embarkation of it; he will prepare pieces of basil as follows, viz.: one for each driver, with his name and station, to tie on his harness; and one for each carriage, with its name and the names of the drivers attached to it, to nail on the head of the harness-vat. The jobbing smith is to be one of the men told off for the forge; the wheeler for the wheel carriage; and the non-commissioned officer or gunner in charge for the spare ammunition and store waggons; the collar-maker will superintend the harness. The men thus told off will amount to about thirty-two, which will be sufficient for the embarkation of the guns and carriages; the other men will be required for the horses.

9. On the arrival of the battery at the place of embarkation, it is to be drawn up

in line, in column of half-batteries, or of divisions, according to the space, but in as compact order and as close as is consistent with the due performance of the multifarious operations which are required. The horses are to be taken out, and drawn up in the same order as the battery; close to it if there be room; if not, in the most convenient spot near at hand. The harness is to be taken off and packed; and the horses will afterwards be led to the place of embarkation as they are called for.

10. A harness-vat should be provided for the harness of each carriage; and a large case for each gun and its waggon, and one for each two of the remaining carriages, as also one for the lighter articles of the store waggon. Into these cases many of the stores are to be put, such as intrenching tools, lanthorns, forage-cords, picket-rope, prolonge, &c., and any of the smaller articles. These vats and cases are absolutely necessary when it is known that the voyage is likely to occupy more than a few days, or when more than one battery is to be embarked in the same ship, or when the ship is likely to be crowded. In disembarking they must be carefully preserved, headed up, and sent on board the transport, or into store. When there are no cases, the stores must be secured to the carriages, or tied together as firmly as possible: the intrenching tools may remain with the carriages.

11. The harness for each carriage should be embarked with it, because in the event of a horse ship being lost, the horses may be replaced, but the harness cannot. Each set should be well secured together with a forage-cord or lashing-rope, and a piece of basil with the driver's name tied to it. The harness for each carriage should be packed under the superintendence of the collar-maker in a separate vat, which should be placed near the horses: one of the gunners will receive from the non-commissioned officer some tacks, and the piece of basil with the name of the carriage, which he will nail on the top of the vat: as soon as the harness is packed, the gunner will put on the head of the vat and nail on the chine-hoop inside the staves; after which the vat is to be rolled close to its own carriage. When there are no vats, it is still more essential that each set should be well secured together, as before stated; the sets belonging to each carriage will then be collected and placed close to it. The harness is the last thing to be embarked.

12. If there be room to draw the battery up in line, and that all the carriages are to be embarked in the same ship, the waggons will cover their respective guns; the other carriages in two lines, viz., the spare ammunition waggons on the left of the guns, the wheel carriage covered by the store waggon, and the forge on the left of the whole. When the carriages are not all to be in the same ship, the additional carriages must be equally divided among the subdivisions.

13. If, from want of room, the battery is drawn up in column of divisions, and that all the carriages are to be in the same ship, the spare ammunition carriages, wheel carriages, store waggon, and forge, are to be at the head of the column: when the carriages are to be in different ships, these carriages are to be equally distributed among the subdivisions.

14. If boats are to be employed, their number will, of course, depend upon their tonnage; and their loads must be regulated by the state of the weather, and the distance of the vessels.

15. In embarking from a beach, it may be necessary to erect small sheers, made of a couple of top-gallant masts, which should be previously prepared for that purpose.

16. If the embarkation takes place from a wharf, the battery must be drawn up in the most convenient place near at hand, and every thing prepared as directed. If there are cranes, and the boats are much below the top of the wharf, the guns and ammunition boxes should be lowered into the boats by means of them; but when the gunwales are nearly level with the wharf, the ammunition boxes may be more ex-

peditiously put on board by hand; and if there are no cranes, the guns may be parbuckled into the boats. Light 6-pounders are easily managed, but these directions apply more particularly to the 9 and 12-pounders.

17. The men told off to the carriages will prepare them for embarkation. They will take off the side-arms and secure them together, take out the elevating screw, unkey the cap-squares, scrape the wheels, unlash the ammunition boxes, and coil up the lashing-ropes. Each carriage when called for is to be run forward to the boat or crane; the gun is to be unlimbered and dismounted; the ammunition boxes, shafts, wheels, &c., &c., to be taken off; the washers and linch-pins must be carefully put away in the slow-match box, and in the small box between the limber boxes: if they are left in the axle-tree, they are liable to be lost.

18. An intelligent man from each subdivision must be stationed in the hold, that he may be acquainted with the situation of every thing belonging to it. Every article must be stowed away with the greatest care, and arranged in the best manner possible, so as to be got at without delay: the marked side should invariably be in sight, which will often save much trouble and delay in disembarking.

19. Those articles which will be the last required when disembarking are to be the first to be embarked. When all the carriages are to be in one ship, the divisions and every thing belonging to them should be kept together as much as possible. The first carriages to be embarked are the spare ammunition waggons, store carriage, wheel carriage, and forge; these are to be stowed forward: the third division next to them, and before the main hatchway: the second division next to the third; and if any part of it comes under the hatchway, the first division must be put on the top of it, directly under the hatchway: if there be room, the second division may be stowed abaft the hatchway: the whole of the guns are to be together directly under it. Should two batteries be embarked in the same vessel, they should be stowed away on different sides of her.

20. The guns should generally be in the bottom of the hold; their vents turned downwards, and a fid in them to prevent their being choked. In some cases when the battery is a light one, two of the guns, light 6-pounders, may be lashed on the deck, if the voyage is not likely to last more than two or three days.

21. When the battery is embarked in different vessels, every part should be complete, and a proportion of general stores be on board of each, so that, in the event of the loss of a ship, the remaining part of the battery may not be disabled.

22. If the voyage is likely to last more than a day or two, the cartouches with the ammunition must be taken out of the boxes, and stowed in the magazine: one or two intelligent men in the hold must be told off to this duty. The ammunition must be so placed, that whatever part belongs to any particular carriage may be got at without difficulty. When the cartouches are not taken out, the boxes must be stowed well aft in the hold, or between decks, and they should be well covered with wadmilltilts, hair-cloths, or the tents of the battery.

23. When the disembarkation is likely to be opposed, the transports should not be loaded or lumbered up with any thing which will occasion delay in getting out the battery, that may be required to accompany the troops in the immediate advance, or which may be necessary to cover the landing of the main body of an army.

24. When no opposition is expected, the vessel may be more filled, but the battery should be so placed as to be most readily got at.

Embarking the Horses.

25. The embarkation of the horses is of more importance than that of the guns,

particularly if it be necessary to take them alongside the vessel in boats; when in bad weather the guns and carriages are easily hoisted in, but the horses cannot be: if the embarkation of both therefore cannot go on at the same time, the horses should be embarked first.

26. The horses are to be embarked in the same order as the carriages, taking care that the officers' and non-commissioned officers' horses are on board with the subdivisions to which they belong. The farriers and shoeing-smiths should be distributed in different ships, and those which have none should be visited by them during the voyage.

27. The embarkation of the horses on board all the ships should as much as possible be going on at the same time. If in boats, the first that comes should have a proportion for one ship, the next boat for another ship, and so on; as by attempting to complete one ship before another is begun upon, it will often happen that the horses are kept waiting alongside, and the other ships are unemployed.

28. Horse ships are always provided with slings for hoisting in the horses; they are made of stout canvass, and are about $6\frac{1}{2}$ or 7 feet long, and from $2\frac{1}{4}$ to $2\frac{1}{2}$ feet wide: these should be minutely inspected by the farrier and shoeing-smiths, and if their appearance is in any degree suspicious they should not be used, but new ones prepared, which, when there are materials, should be made by men of the battery.

29. There are different ways of embarking horses, which arise from local circumstances, and each of them requires a different mode of proceeding.

30. *First.* When the transports can come alongside the wharf and take the horses on board at one operation. *Second.* When the transports cannot come alongside, and that it is necessary previously to embark the horses in boats. *Third.* When the horses are embarked in boats from an open beach; or when the gunwales of the boats are nearly level with the wharf, either from its being high water, or from there being little rise or fall of the tide.

31. The embarkation of horses from a beach, or from a wharf, in boats, as also the hoisting them from a wharf when the vessel is alongside, is carried on by the artillerymen, assisted by the sailors. When the vessel is at a distance, the men who are in the boats with the horses must assist the sailors; and it is desirable that an Officer should be on board to superintend.

32. The first case (see No. 30) is the best, easiest, and most expeditious; resembling in all respects the hoisting a cask in and out of the hold. The following preparations in the ship are necessary: The main-yard is to be topped up as for hoisting in a boat. A tacle is to be rigged to that part of it, under which the horse will be brought for hoisting in; a leading-block is to be on board, through which the running end of the tacle is to be passed, which may be brought on shore, to give the men a longer run; or it may be kept on board. A similar tacle is to be rigged to the main-stay, directly over the middle of the hatchway, for lowering the horses into the hold; there is also a leading-block to this tacle, but the running end of the tacle is to be kept on board, and the running-block of it secured to the running-block of the main-yard tacle.

33. When the ship cannot come so close to the wharf as to bring the horse directly under the tacle, one end of a strong guy must be secured to the lower block of the main-yard tacle, and a turn or two taken round a post; it must be eased off gradually as the horse rises, to prevent his swinging against the ship: when he is directly under the tacle, the guy must be let go.

34. There must be a double guy made fast to the horse's head, one end of which is to be on shore, the other on board to keep his head steady, and in such a di-

rection that it may not strike against any thing: too much attention cannot be paid to have this rope under command, particularly in lowering the horse into, or hoisting him out of, the hold: for in the former case, as soon as his feet touch the ground, he is apt to spring up, and if his head be not directly under the hatchway, and every thing clear above him, he may strike his head and be ruined. A shoeing-smith should be in the hold of each ship to receive the horses, and if there are not enough for this, they should be sent from ship to ship.

35. Horses should generally be blindfolded, which prevents their being frightened and troublesome. A horse requires at least four men besides the driver to sling him, viz., one on each side, one at his breast, and one behind. One end of the sling is passed under his belly, and both ends made to meet over his back; one of the men passes his loop or handle through the other; it is received by the man on the other side, who hauls it through, hooking the tacle to it, both men holding up the ends of the sling. The men at the breast and breech bring their ropes round and make them fast to the grummets or thimbles. The driver holds the horse's head, and makes fast the guy to it.

36. The horse being ready, the word '*Hoist-away*' is given, and the men at the main-yard tacle whip him up, the slack of the stay-tacle being hauled in as the horse rises, his head not being let go till he is fairly off the ground, and deprived of the power of injuring himself. When the main-yard tacle is high enough, a turn is to be taken with the fall of the stay-tacle, round a belaying-pin, and the main-yard tacle eased off till the horse remains suspended by the stay-tacle alone, and hangs directly over the centre of the hatchway; the stay-tacle is then eased off till the horse is in the hold. The slings are then taken off, and he is led to his place and baled up; the first horses always being led forward, or aft, as the ship fills; the stalls nearest the hatchway being reserved for the horses which are first to be landed.

37. The second case (see No. 30) is more tedious; double time is required to hoist and lower the horses, as each operation must be twice performed; to this must be added the time occupied in the passage of the boats to and from the vessel.

38. Sand or straw must be put into the boats to preserve their bottoms, and to prevent the horses slipping. They should stand athwart, the head of one horse being on the starboard side, and the head of the next to him on the larboard side. The drivers are to sit on the gunwale, or stand between the horses.

Vide 'Derrick.'

39. Sheers or a derrick are absolutely necessary, because the tacle must be of such a description as to raise the horse off the ground instantaneously, which a crane cannot do. There are boxes, into which the horses may be made to walk, and which may then be raised by a crane; but these boxes cannot be expected, or even used when many horses are to be embarked. The head of the derrick must incline inwards while the horse is rising; but when he is high enough, the head of the derrick or sheers must be forced out, to bring the horse directly over the boat. Horses may in this way be embarked in boats from a beach.

40. Decked gun-boats or coasting vessels are very convenient, when there is time and materials to make the necessary preparations. In addition to the greater number of horses which they will hold, when compared with the transport-boats, an important consideration is that they can be used for horses in weather when the others cannot, but which, however, may be available for other purposes; a want of boats being always the subject of complaint in embarking and disembarking. As the decks of these vessels have sometimes a considerable slope, it will be necessary to lay a flooring of plank, and to make fast a spar on each side to prevent the horses slipping. A double line of horses may be embarked when the vessels are large, the

one line standing on the larboard, the other on the starboard side. These boats may come alongside a wharf, and the horses can walk on board by the means of a small bridge or ramp of planks.

41. In the third case (see No. 30) the horses are to be led to the boat, and the halter given to one of the men in it, who will pull him forward, whilst the others push him behind and urge him with the whip, in order to make him leap at once into the boat; for if he only gets his fore feet in, they may slip; he may then overreach himself so as to be unable to get in, and he may be strained. A quiet horse should first be embarked, as the others will follow more readily when they see a horse or two in the boat. Care must be taken to trim the boat by turning the horses' heads successively to and from the shore as they are embarked. When the embarkation takes place from a beach, the gunwale of the boat should be inclined towards the shore, that the horses may the more readily jump in.

42. When a horse falls sick on board ship, and that it is necessary to remove him nearer to the hatchway, the bales between him and the stall into which he is to be shifted are to be taken down; the heads of the horses in those stalls are to be turned from the sick horse, and he is to be led close to the manger past them: the horse which stood next to him is put into his stall, and the others are closed in. A stall or two should always be left vacant for sick horses.

43. The ground on which the horses stand should occasionally be levelled: by removing the bales, the horses can be put close together, and the vacant space may then be made smooth; this is practicable at any time, unless the weather is very bad.

Disembarking.

44. When there is no particular hurry, and no enemy to oppose the landing, the disembarkation is exactly the reverse of what has been detailed. The harness is the first thing sent on shore. If the water be smooth, with little surf, the disembarkation may easily be carried on upon the beach; the horses will leap out of the boats, and on any emergency, if the vessels are near, they may swim ashore; but this is not recommended, as the sudden transition from the heat of the hold to the cold of the water may be prejudicial, particularly as the horse cannot be well dried, as every person is fully employed in more essential duties.

45. In disembarking, great care must be taken of the vats and cases; they should be headed up and preserved. (See No. 10.)

Embarking when an Enemy is present, or close at hand.

46. It is natural that an Artillery Officer should wish to embark all that he can as soon as possible, in order to have less to put on board when the last of the troops are embarking, or less to lose; but the probability or possibility of leaving some guns should never be put in competition with the more important consideration of keeping on shore to the very last a force of artillery sufficient to repel any attack. The horses and all the carriages should be previously embarked, except the guns and limbers, in such proportion as is calculated for the position to be occupied: if it be near the water, the limbers may also be sent off, and the guns dragged to the boats by men. A sufficient supply of ammunition should be at hand in a boat or two, close to the shore. If the position be a mile or two from the place of embarkation, it may be necessary to retain a proportion of horses.

47. The guns which are last embarked are generally put on board the launches of men-of-war, fitted for the purpose, as follows: two planks are laid from the bow to the stern, parallel to each other, at the distance of the span of the wheels; a bead is

nailed to the inside edge, to prevent the wheels from slipping off. Two gang-boards, which can be laid out or taken on board, are fitted to the bow ends of the planks, so as to reach from them to the shore as a ramp; and a third one is sometimes fitted to receive the trail of the carriage: by means of these the guns can be run into the boat with the greatest ease. These boats are towed by smaller ones.

48. If the enemy be actually present, the embarkation of the last of the troops generally takes place at night.

Disembarking when opposed by an Enemy.

49. In this case, the guns attached to the division of troops which is first to land must be put mounted into the boats, fitted as in No. 47. It is very desirable that this portion of the artillery should be embarked on board men-of-war, with the Officers and men attached to them; or if not the whole, at least the non-commissioned officers and a few of the gunners to look after the stores; the Officer and the remainder of the men joining previous to the disembarkation. Each two-decker can take a couple; the guns are stowed away on the upper deck, the carriages and wheels in the chains, so that the guns can be mounted and ready to be lowered into the boats in a very few minutes. The ammunition is to be taken out of the boxes, and placed in the magazine.

50. If the guns are on board transports, the boats may come alongside, and the guns be lowered into them as already described. The possibility of this occurring shews the absolute necessity of the battery being embarked by its own Officers and men, (see No. 3,) when the smallness of the transport's deck and her crowded state must produce great confusion.

51. The muzzle of the gun must point forward in the boat, and as soon as the boat takes the ground, the gang-boards are to be put out, and the gun run on shore, which can be done in five minutes in tolerably smooth water. At first landing, the gun is generally drawn by sailors, an artilleryman guiding it at the trail; and it is, therefore, better that the limber should accompany the gun, which, with its ammunition, is then much more easily moved. When the limber is not with the gun, the ammunition must be carried by men, which is very fatiguing; the limbers should, therefore, follow as soon as possible.

52. The artillery should endeavour to gain the shore, and land with the troops, whose object will be to take up a position to cover the landing of the main body; and a sufficient supply of artillery ammunition and stores, in the common deal laboratory boxes, should be in a boat or two close to the shore. The landing is generally covered by the smaller frigates, and by boats fitted with carronades.

53. By removing some of the forward thwarts of the boat, the planks for the gun-wheels can be laid with a slope, and one gun in a boat be fired to cover the landing; this slope should be about 3 inches to a foot, which will diminish the recoil to 1½ foot. From these, two short planks should be laid, leading to the gang-boards; these may be fixed, or they may be laid after running the gun back; there must also be a centre plank for the trail to recoil upon. The muzzle of the gun, when fired, must be well above the bow of the boat, so as not to shake it. This plan answers perfectly in the flat boats, which, though apparently slight, will stand a round or two very well. These boats are most useful; they are not high out of the water, and stores can be more easily embarked in them than in any others from a beach; but heavy stores are apt to damage them.

SECTION II.

OBSERVATIONS ON THE PROVISION FOR EMBARKING AN EQUIPMENT OF HEAVY ARTILLERY FOR A SIEGE.*

1st. The first things to be considered are, the place to be attacked, its strength, its position, whether distant or not from the spot where the disembarkation is to be effected, the ordinary means of transporting heavy ordnance and stores which the country possesses, and whether such may be calculated on with certainty and made available: all this should be entered upon to arrive at the nature and extent of the equipment to be forwarded—not only as to the number and nature of ordnance and ammunition, but of the carriages and stores which are essential to complete this equipment in every particular, without encumbering it with burthensome and useless articles which experience and foresight may shew can be dispensed with.

2nd. The particulars of the equipment being thus decided on, one list in detail is to be prepared for the Executive Officer, or Storekeeper of the Ordnance, who is to furnish the supplies,—and the duplicate to the Superintendent of Shipping, who is to provide freight. The burthen, *i. e.* weight and measurement, of the whole equipment should be made out with as much accuracy as possible, so that such ships may be engaged as will give an ample, but not excessive, amount of stowage-room. Having thus arrived at the tonnage necessary for the whole, such a distribution should be made as may equalize the *quantities* and *description* of ordnance and stores which each ship should contain, so that in event of any vessel being lost, there may be no undue deficiency in any one particular respect.

3rd. To arrive with some degree of accuracy at the tonnage required for the conveyance of a large equipment of ordnance and stores, considering the multiplicity of articles comprising it, varying extremely in weight and bulk, it appears to be an object of great importance that the Admiralty should possess (what I have never yet seen) what may be called a Tonnage-Book, in which should be arranged alphabetically the weight, and measurement in cubic feet, of each piece of ordnance in the Service,—of those carriages, stores, &c., which are known as the indispensable accompaniments of each such piece of ordnance: the like arrangement may be made for Engineer stores. The labour of such a work would be much abridged by considering the various small stores belonging to each gun, &c., as being packed in one or more boxes or cases, of which the bulk and weight should likewise be entered in the Tonnage-Book: this would, moreover, enforce a regular system of keeping together the various small stores which belong to each piece, and would thus be immediately available, if necessary, on the latter being landed.

4th. In preparing for the embarkation, considering the Office arrangements as having been made by the allotment to each ship of the particulars which it is intended each shall receive, (their magazines to contain powder being carefully provided and in all respects ready,) whether a single ship or a dozen be necessary to contain the equipment, the plan for adoption which suggests itself to me as best, by combining expedition with accuracy, is as follows:

Run the carriages with their ordnance stores and ammunition (not powder in any shape) upon the wharf, and arrange them by the side of the ships into which they are to be embarked; painters to be employed on the wharf in lettering each carriage and boxes containing the respective stores, with the name of the ship; and other artificers, for cleating iron-work on carriages and boxing linch-pins and washers when

* By Mr. Butcher, Ordnance Storekeeper, Dublin:—and at the Siege of St. Sebastian, 1813.

taken from carriages. Boxes containing case, grape, or spherical case, to be packed in separate stacks according to their nature; and the stores of a general character grouped together in such a manner as will admit of the whole being at once seen to be complete and ready to be shipped.

1st. The heavy guns, and mortars with their iron bed, as well as loose round-shot, which should be placed in the bottom of the hold, arranged on each side of the kelson, fore and aft, for the entire length.

2nd. The carronades and howitzers, which, being considerably lighter, should be placed above the guns and round-shot, but as nearly as possible in the centre of the hold or plumb with the main hatchway.

For the better elucidation of my views of embarkation, see figs. 1 and 2, by which the ship's available stowage (after providing for the magazine) is *supposed* to be divided into 27 sections, *i. e.* 3 longitudinally and 9 transversely, which in every ship's bill of lading would be described in reference as larboard, centre, or starboard, from 1 to 9. The object in this is, I think, important; for as in many instances where a ship's cargo is not to be landed in toto, but certain stores only that may be urgently wanted, it is of consequence to know in what part of a ship they are to be found, and thus prevent the serious trouble and delay which in my own experience has generally occurred for the want of some such arrangement.

Fig. 1.

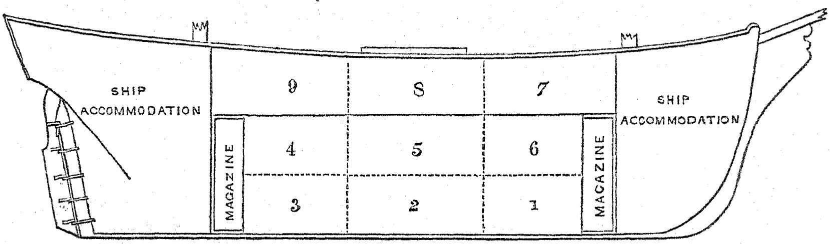
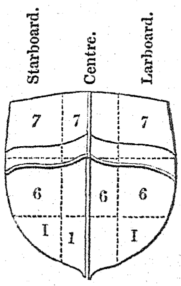


Fig. 2.



3rd. Having disposed of the ordnance and loose shot, the location of the remainder has to be considered with reference as much as may be to the trim of the ship, but more especially to the order in which the stores are usually required to be disembarked; therefore the travelling carriages and the general stores as packed in boxes belonging to each piece should come next, keeping such stores always together,

in order that in disembarking any one gun there should be no impediment to its instant completion.

4th. The store carriages, of all denominations, and all such general stores of a nature that cannot be required until the Engineer stores and the ordnance with their carriages and stores are landed, should be stowed, as far as practicable, together in the after part of the hold, thus providing for carriages on which to move the guns on being disembarked, and the stores immediately required for them, which should be with the guns.

The ammunition in boxes, such as case, grape, and spherical case, (care being taken that those for each calibre are placed together,) may be disposed of with reference to the trim of the ship, remembering to leave ample room for Engineer stores, which should be most immediately accessible, as being always first required.

Powder in barrels, or in filled cartridges, should be the last embarked.

In conclusion, it should be observed that the general rule for embarking stores, is, "first wanted, last packed," with exception of combustibles and powder, which, as above, must always be sent on board last; the ship's bill of lading furnishing a guide to the section of the ship in which any particular stores are placed, not with any critical accuracy, but as nearly as the eye can judge by the main dimensions of the space allotted for stowage. It admits of a doubt as to whether the course now recommended gives the most *compact* mode of embarkation by which *no* space will be lost; but it is conceived that the necessity of having every thing at hand is paramount to all considerations of at best but doubtful economy.

SECTION III.*

EMBARKATION OF HORSES.

Vide Section I. 'Embarkation' of Field Artillery.

1. Horses require great attention at the time of embarkation, and while they are on board ship; and it is expected that every Officer of the cavalry will feel that he has a most important duty to perform on these occasions, on which depend, in fact, the means of his being usefully employed in the field, when he reaches his destination.

2. It is of the utmost importance to the future health of horses that they should not be heated at the time of embarkation. With this view it is desirable that a hurried march, on the day of embarkation, should be avoided; but as horses are much less liable to be injured by the operation of slinging after having undergone moderate exercise, and as they are then more disposed to be quiet and manageable than when fresh from quarters, their march previously to embarkation is to be regulated accordingly. They are to remain saddled until brought alongside of the ship, time being allowed for wisping them over and picking out their feet.

3. The breast and breech-ropes of the slings are to be made fast by an expert seaman, so that the knot, which is to be securely tied, may be easily loosened. The tacle is to be hitched on, and the horse run up quickly, in order that he may be deprived of the power of plunging and doing mischief. A web-headed halter with two reins, to be provided as ship's stores, is to be put on each horse before he is lifted from the ground, and the reins are to hang loose. The fixing of the guide-ropes, the bringing him over the hatchway, and conducting him through it, are to be done by the ship's company.

4. When the horse is deposited in the hold, and released from the slings, it is the

* From the Queen's Regulations.

duty of the ship's carpenter to fix the bales which are to secure him: a lock of hay offered to the horse will tend to soothe his fears, and reconcile him to his new situation. As soon as all the horses intended for one ship are put on board and properly secured, they are to be fed with hay and watered.

5. On the first night of being on board, the horses are to have a mash with some nitre, and during their passage bran is to make a large portion of their daily ration. Care is to be taken that they are not heated by being over-fed: the small but sufficient ration allowed will guard against this evil; but judgment must be exercised in its distribution among the different horses.

6. The face, eyes, and nostrils of each horse are to be washed with a sponge and sea-water at the regular stable hours.

7. If a horse refuse his food, an early bleeding will in general restore him; but the object which, of all others, requires the greatest attention, is that the *hold* be well ventilated by means of wind-sails, the ends of which ought to be at different parts of the hold, and the number of them in proportion to its size and depth. A proper supply of pure and fresh air must be secured.

8. In cases where, from bad weather or other causes, the hold has been kept more than usually close, great advantage will be found in washing the manger with vinegar and water, and occasionally sponging the nostrils of the horses with the same.

9. It is necessary that at least one stall on each side of the transport should remain vacant, and some spare canvass is to be provided for slinging the horses to the bales between them, in case of illness or accident.

10. After disembarkation, a cooling moderate regimen and gentle exercise are the best means of restoring the horses to their wonted vigour, and preparing them for service: indeed they should be treated with the same caution as is observed in regard to Remount horses.

SECTION IV.*

DISEMBARKATION OF INFANTRY.—REGIMENTAL ARRANGEMENTS TO BE MADE.

The arrangements necessary will depend much upon the service to be performed, and the intent with which the men are landed. In some cases they are thrown on shore for a few days or weeks, only retaining the line of *sea-coast* as their base of operations. In others, they are landed for permanent operations, when, though they may still draw some of their supplies from the shipping, they cease to consider the fleet as their refuge from defeat, and the storehouse for their daily supplies.

For temporary and flying operations along a coast, the men should be landed as light as possible, and no *baggage*, mules, or horses, should be allowed to encumber the movements of a force liable each moment to be re-embarked, either to relinquish the operations altogether, or to effect a fresh landing at some other point. Men and Officers, therefore, must carry only what is absolutely necessary to enable them to exist and do duty; and this depends very much on the state of the weather and the height of the thermometer.

At a temperature by day from 50° to 70°, the soldier's equipment should be the clothes he stands up in, with a knapsack containing 1 great coat, 1 pair of stockings, brushes, soap, and towel; rags for cleaning musket, and 40 rounds of spare ball ammunition; and in this case he lands in cloth trousers.

At above 70° he should land in white trousers, and take his cloth ones in his pack

* By Captain Rea, Royal Marines.

for night service; for I have seldom seen men fresh from a ship able to undergo much exertion in warm weather, if too heavily clad.

Under 50°, service of this nature should not be attempted unless you can give men either tents or blankets.

The first duty of the Regimental Officer is to see that the men do not take more clothing, &c., than is ordered. He should next have two days' meat *cooked*, and issue that and four days' bread, taking with him the usual proportion of small-sized camp kettles and cutting tools.

The rations of wine or spirits should not be issued to the men, but must be put in convenient-sized barracoes, and carried by men told off for the purpose, until better means of conveyance (such as carts or horses) can be seized from the enemy or hired of the peasantry. About 4 men per company of 70 men should also be provided with bearers for the conveyance of wounded men and for the supply of stores, &c.; these men should not be armed.

When ordered to land, Commanding Officers should if possible have accommodation-ladders shipped, as it is a very slow process getting troops into boats without them. If opposition is expected to the landing, the muskets may be loaded before leaving the ship, but should not be primed for fear of accidents (speaking of detonators); they must prime in the boats; but packed as troops usually are for landing, they could scarcely load in the centre of a boat.

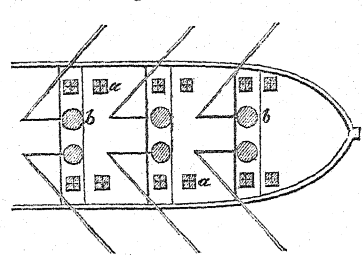
A proportion of Officers and non-commissioned officers belonging to the company should go in each boat; and no company should be broken up more than is absolutely necessary; they should be told off as a company before leaving the ship.

The Officer commanding the troops in the boat should be in her *bow*, ready to jump out when she touches the beach, and a non-commissioned officer should be in the stern, to hurry the men in clearing her.

In getting down a ship's side without accommodation-ladders, the men should slip the hand between the sling and musket just below the top swivel, so that the musket hangs by the wrist; this allows both hands for the side-ropes: the sling is not to be loosened out.

The first men in the boat must be made to move to her bow and stern, and not allowed to crowd in the centre, which they are very apt to do, and which causes very great delay. Old hands will generally avoid going into the bow of the boat, for fear of a wetting; the best remedy for this is the example of the Officer.

If there is any motion, care must be taken not to overload the boats, for fear of their swamping; there will therefore be *room* for the crew to pull. As many of the troops as possible must be made to sit down in the boats: in a barge or pinnace one soldier between each rower and the rowlock, before the oar, looking aft, and one abaft each oar, with his back to the gunwale, thus: *



* The ○ are sailors, the ⊞ are soldiers.

In launches or larger boats there will be room for men to sit or stand in the centre of the boat between the two lines of rowers, in addition to those marked for barges, &c. The head and stern sheets of all boats to be packed as close as possible consistent with safety.

If the water is perfectly smooth, the boats may be laden much deeper, the men standing as close as possible together; but in this case they must be towed, for two reasons: 1st, the crew have no room to pull; 2nd, when boats are very deep, the men cannot get the blades of the oars out of the water so as to pull with effect. It must, however, be remembered that it is slow work towing a heavy boat by a light one; load, therefore, the boats employed in towing as deeply as you can without inconveniencing the rowers.

Boats employed landing troops are to have neither guns, masts, nor sails; their equipment to be, gang-boards, oars, grapnels and painters, boat-hooks, bailers, hammers and nails, sheet-lead, grease, and canvass; the latter articles to enable them to stop a small shot-hole in case of accident.

The number of boats to be sent in *a body* to the shore must depend on the quantity of beach disposable for landing. Suppose there is 100 feet of beach, and that the boats take 10 feet each. If more than ten boats are sent together, they make confusion at the landing-place between light boats coming out and loaded boats trying to get in, in narrow beaches; therefore throw the boats into divisions of ten, and start them thus in succession, so that the one division should land their men and be clear off the beach just as the next arrives. To insure regularity in this, it is indispensable that there should be an Officer of *rank and authority* as *Beach-master*, and another afloat, superintending with the fleet.

When the place for landing has been determined upon, don't stand looking at it; get the men into the boats ready to pull in, send in your small craft and *armed* boats to open a fire on the spot, particularly any cover within musket-range of the beach, in two lines abreast; but once the men come under fire, they will always exert themselves to get in: the fastest boats therefore will reach the beach first; nor is it any inconvenience that one boat should be 40 or 50 yards before another.

Landing in a surf is always a dangerous and difficult operation,* nor can any general rule be laid down, as plans that succeed at one place are found to fail at another: the opinions of experienced Naval Officers should be taken, and also the advice of persons acquainted with the locality. You must not expect to keep your men dry in landing through a surf. Take care the boat does not come broadside on *while in* the surf; after she is beached it is of less consequence. Flats are better than keel-boats for that purpose. The best general instruction that can be given is to watch the sea, and go in on the *top* of the highest surf, flinging your long painter on shore as the boat goes in. Men on shore must seize it, and run the boat up as high as possible, and hold on to prevent her being drawn out by the reflux. The men must jump out as quick as possible after the water leaves her, for the next sea will, if she is deep, probably fill her.

Should the next sea lift her stern, haul on the painter and get the boat as high up on the beach as she will come. If she be thrown broadside on to the surf *while* her bow is well up on the beach, it is seldom of much consequence, provided the men jump out quickly, and she is not allowed to fall over with the bottom of the boat towards the shore.

It is to be recollected that this arrangement is for the infantry landed for tem-

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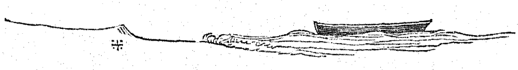
* *Vide* latter part of Section V.

porary service, without baggage, guns, or stores, and opposed only by troops or guns in the open field, and not protected by works of any kind.

They must be very liberal with round, grape, and canister, and under cover of the fire the boats should pull boldly in, recollecting that the men are to be landed, and that the sooner it is done the better; the fire of the shipping only ceasing when there is danger of injuring the wrong men.

The men in the first division are, of course, those to be depended on; and the Officers having been shewn their ground, as the boats approach the beach, each should select the best shelter he can to form his men under; this he will frequently find just above high-water mark, where the sea generally leaves a small ridge.



As soon as the boat grounds, the Officer jumps out over the bow, followed by the men as quickly as possible, taking care that they do not all rise up together, or jump out over any part of the boat but the *bow*. If the boat is large, or there are rocks so as to render it unsafe for an accoutred man to jump, the gang-boards must be used, the men quickly following the Officer away from the water's edge to the sheltered spot he has selected for his formation, from whence he must open fire or advance at discretion, without waiting to be joined by the men from other boats: he is to consider himself part of a line of skirmishers, the supports of which line are in the second division of boats.

As soon as each boat is clear, she must shove off and pull to the shipping for a fresh cargo; waiting, when full, alongside of the ship for the rest of her division of boats.

The second division of boats will land as the first, getting the best shelter they can to form, but they will not commence firing until the whole of each company has joined, when they will act as supports under the command of their proper Officers, or according to circumstances.

As soon as a sufficient number of completely-formed companies are on shore, the irregularly-formed skirmishers first landed will be relieved, formed, and sent to their respective battalions.

As the advance gets sufficient room for the points of formation (for battalions must be such a distance from the beach as to prevent confusion at the water's edge), steady non-commissioned officers will remain on the beach to direct the men of their respective regiments in what direction to go on leaving the boats.

A very small space suffices for landing, but should it be greater, more boats will, of course, touch the beach at one time, and then it will not be necessary for *all* the men first landed to be thrown out to skirmish, but the troops of a certain number of boats will be told off for that purpose; the remainder forming regularly. It should, however, be particularly noted that no time is to be lost in striving at too much regularity: a certain number of the men first on shore must always dash on as soon as possible to gain cover and room for those that are to follow.

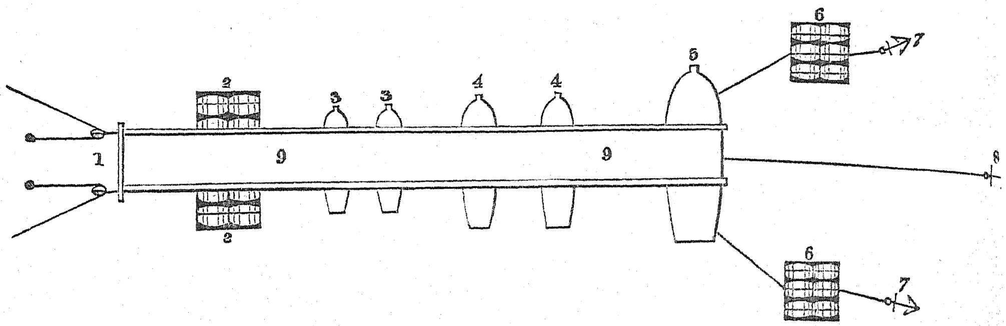
For landing provisions, stores, and guns, seize some small convenient pier, or failing that, erect good substantial derricks (*vide* 'Derrick'), recollecting that the shipping abound in spars, rope, blocks, &c., &c., necessary for the purpose.

The best description of carpenters, smiths, ropemakers, sailmakers, are to be had from on board ship.

Vide 'Bridge,' Plate VIII.

It is conceived that for the purposes of landing troops and stores, a half of a

bridge, similar to some of those described in Sir Howard Douglas's work on Military Bridges, might be constructed from the boats of a line-of-battle ship thus:



1. Bridge end fastened to the shore.
2. Raft of casks in the shallow water; the end next the beach to be protected with fenders of bags of oakum, or fascines, to prevent the heave of the sea from staving the casks by thumping them against the bottom.
3. Ship's cutters.
4. Pinnace and barge.
5. Launch.
6. Two rafts of casks, capable of bearing about say 6 tons each, hove partly under water, so as to act as a *spring* on the bridge and keep all taut, and also to prevent a downward strain on the outer boat, these rafts bringing the strain parallel to the surface of the water.
7. Heavy anchors, with a long scope of cables, say 100 fathoms each of 8-inch hawsers.
8. Anchor for hauling out the bridge on the fall of the tide, so as to keep the raft at the inner end always afloat: this hawser to be slacked up when a vessel goes alongside the bridge end.
9. Two-inch deals, 10 feet long, laid on five 6-inch hawsers. To form the roadway of the bridge, the planks must be 2 inches apart, to allow the sea to wash between them, and prevent their being blown up.

Oars, boats, masts, and small spars, should be laid, running the whole length of the bridge, lashed over the ends of the planking to the hawser beneath, to prevent too much spring in the bridge.

Such a structure, from its being very *flexible*, would, it is supposed, stand a considerable sea.

Small steamers might go alongside the end of it, while boats could put men on its side.

ADVANTAGES.

Fifteen feet of beach or rock is all that would be required; small spots, therefore, might be selected for a landing where the enemy had no troops. Generally, wherever the beach is extensive for a landing, a strict watch would be kept; but it is impossible to watch every small nook of from 10 to 30 feet landing-place.

Such a structure might be put together out of gun-shot, and towed in: with proper drilling, half an hour would probably anchor it and secure all taut.

In re-embarking there would be no danger of the boats becoming hard and fast ashore on their being loaded, which sometimes takes place now, and men are at times obliged to land again to get a boat afloat.

In re-embarking under fire, the rear-guard might run on the bridge and cut it away, and take their chance of being towed out of range by a steamer.

With such a structure, a force would land in one-tenth of the time now requisite to land them in boats.

When one of Blanshard's large bridges is embarked, and is not immediately required for operations on shore, it might be thus used for a short time; but from the rapidly destructive action of salt water on most metals, these tin cylinders should not remain in the sea longer than can be helped. If the moorings are once down, the bridge can be rapidly thrown out and withdrawn again at any time.—*Ed.*

Vide 'Bridge.'

SECTION V.

FRAGMENTARY NOTICES OF NAVAL ARRANGEMENTS FOR DISEMBARKING TROOPS.*

In landing without opposition, advance in line, abreast, with as few men in the bow of the boat as possible, which will enable her to be laid high on the beach, and prevent the men from getting wet.

When opposition is expected, the troops intended to be landed from men-of-war or transports, in an enemy's country, should have on the previous night three days' provisions ready cooked and served out as they are leaving the ship. When in the boats, they should rendezvous at the nearest ship in-shore; when ready, advance in line, covered by the launches and all other boats carrying guns, and flanked by frigates and brigs as the water will allow. A Subaltern's party should be named to advance to an height, to observe what is going forward while the battalion is forming, which will then advance and leave the beach clear for the next detachment.

N. B. All boats should be provided with a grapnel or small anchor, with 15 fathoms of rope, to be let go on approaching the beach, so as to be able to haul off when required.

Any number of soldiers that can be conveniently carried without lumbering the oars or loading the *bow* may be stowed in the boats.

All boats should be provided with two buckets for bailing in the event of their being struck by shot, in which case a tallow plug, or a seaman's jacket, should be quickly placed in the hole: should there be extra ammunition in the boat, it should be removed into the stern-sheets and kept dry.

When the launches and pinnaces, &c., are entirely filled with troops, they should be towed by as many *small* boats as can be spared from the fleet.

Each boat should be furnished with two planks that would stow between the after-thwart and head-sheets: or if this cannot be done, let them be slung over the gunwale. These planks, when nailed to a batten on each end, will enable the soldier, who at all times is heavily laden, to have confidence to embark or otherwise without wetting himself.

All men-of-war boats have gang-boards, which will answer when you cannot get broader ones.

LANDING ON SURF-BEACHES.

Troops cannot be landed in a heavy surf without great risk. The boats of the country where the service takes place, will answer better than our own (perhaps), and, if they do, I should take the liberty of borrowing a few for a short time.

But I should push for a river or get within a reef, if possible. Beaches defended by surfs are generally accessible before sun-rise in *moderate weather*. You can land

* Gleaned from the correspondence of an old Naval Officer.

at Madras between 4 and 5 A.M.; by 10 you could only approach it in a Masula boat.

On these beaches there are generally running three heavy surges; if you place your boat on the back of the last, and let the men *pull for their lives*, you may reach the shore,—always keeping her *before* the *sea*, and on no account allow her to broach-to. The moment the boat takes the beach, jump out, and haul her up before the next sea breaks.

SECTION VI. A.

INSTRUCTIONS FOR THE CAPTAINS COMMANDING DIVISIONS, ON LANDING THE TROOPS.*

H. M. S. *Ajax*, 24 Jan. 1801.

When the troops are to be landed by the boats of the fleet, great care should be had, that they are kept at a proper distance from each other, at least 50 feet; and when the situation of the place will admit of it, they are to dress, or take their respective stations, from the right, otherwise from the centre, or left, as may be most convenient, or as shall be previously appointed.

On no account must the boats crowd upon each other, nor are they to break the line, either by getting too much ahead or astern.

No boats are to come into the first line, except the flat boats and the launches having the artillery on board; these last, towed by cutters. The second line is to be composed of cutters only, to attend upon the flat boats, that they may afford immediate relief, should any boat require it, in which case they are to proceed directly, without waiting for orders to give the necessary aid. The third line is to be composed of the cutters that tow the launches, and the boats belonging to each ship will keep in the wake of their respective flat boats.

To distinguish the boats having on board the Grenadier company of each regiment, they will carry the camp colours of that regiment, and the other boats are to form to the left, until the regiment is completed, taking care that the companies are embarked on board the boats in the order they should be in when landed; and the Captains commanding the divisions will consult with the Commanding Officer of the troops, and fix on the best method to obtain this object without confusion.

When the troops are to land, a situation will be pointed out upon the shore, where either the right or left will proceed to: if from the right, the boats to the left must observe open order, that the right wing may not be too much crowded together; and the boats to the right will pay like attention when the left is the point from which they are to form.

Upon no account must any flat boat be nearer to another than 50 feet, and this will afford sufficient space for the cutters and launches in the rear to land between the flat boats, agreeable to regimental order of the troops they have on board.

The flat boats are always to drop their grapnel from their stern at a proper distance from the shore, that they may haul off the moment the troops are landed.

It may often be necessary that the flat boats should pull quick round into an opposite direction, either for retreat or any other cause, in which case it is of the utmost consequence that they should do so together, and in one direction.

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* Section VI. A. B. C., from the 'History of the British Expedition to Egypt,' by Lieut.-Colonel (now General) Sir Robert T. Wilson.

Strict attention must therefore be paid to the signal that will be made upon that occasion; and if no signal is made, they are always to pull to starboard.

The Captains commanding the different divisions will repeat all the signals by the Commanding Officer of the disembarkation; and each Captain should have a rowing-boat attending him, with a careful Officer to carry his orders to the boats of his division.

In order that the flat boats may observe the signals as soon as made, a musket will be fired from the Commanding Officer's boat, which is to be repeated by the Captains of the other divisions. Each boat having the signal-flags on board must be provided with stretchers, that the flags may be seen should the weather be calm; and all signals will be made at a flag-staff, in the centre of the boat.

The Officers commanding the boats must take particular care that none of the troops stand up, as on many occasions it may endanger the safety of the boat.

Each flat boat must be provided with four or five breakers, or small casks of water, that immediate relief may be given to the troops upon their landing, should they require it.

When the first landing is completed, the boats (when ordered) will proceed to those ships having ensigns at their fore-top-gallant mast head; afterwards to those having their ensigns at the mizen, until all the troops are on shore.

When the second landing takes place, the Captains will proceed with their divisions of boats to particular ships, that the regiments may be landed in a collective body; and this is to be observed until all the troops are on shore.

The launches that landed the artillery will proceed to such ordnance ship as will be pointed out, to land the light artillery and stores. Should this service not be requisite, they will assist in disembarking the troops, agreeable to the last instructions.

The Captains of the different divisions will deliver copies of these and all other instructions to the Lieutenants under their orders; and they will give theirs to the Midshipmen commanding the flat boats.

No persons belonging to the boats to be permitted to quit them upon landing, unless by the particular order of the Commanding Officer of the division.

SECTION VI. B.

ADDITIONAL INSTRUCTIONS FOR THE CAPTAINS AND OFFICERS APPOINTED TO SUPERINTEND THE DEBARKATION OF TROOPS, &c.

The Commander-in-Chief having signified to me, that after the troops are landed, the boats under the directions of the Captains of their respective divisions are to be employed in landing the stores, provisions, and water belonging to the army,—

The following distribution of the boats is therefore to take place, in order that the demands made by the different departments of the army may be regularly complied with.

After the first landing is completed, and ten pieces of artillery are on shore, the launches are to repair to the following ships, and convey on shore the guns as expressed against them.

	Launches.	Guns.
Foudroyant . .	2	2 6-pounders, *Monarch* transport.

Should the *Minotaur* and *Northumberland* not join, the following boats will land four howitzers, viz.

	Launch.	Guns.	
Swiftsure . .	1	1	From the *Monarch*.
Diadem . . .	1	1	
Ajax	1	1	From the *Indefatigable*.
Europa . . .	1	1	
Kent	1		To be employed in landing spare ammunition, hand carts, &c., from any of the above vessels that are most convenient.
Dictator . . .	1		

A vessel will be anchored near the shore (having an Ordnance flag flying), on board of which will be the spare ammunition, &c., independent of what will be landed by the *Kent* and *Dictator's* boats.

And the following launches will proceed on board the *Ann* transport, and there receive on board such stores as the Commanding Engineer may direct, viz.

	Launch.	
Stately . . .	1	With cutters to tow each.
Northumberland	1	
Delft	1	
Minotaur . . .	1	

When the whole of the infantry are landed, and the above service completed, the divisions under the command of Captains Stevenson, Morrison, Larmour, and Apthorpe, assisted by Captain Gunter, P. A. T., after placing dunnage in the boats' bottoms, are to be employed in landing the cavalry of the reserve, consisting of 234 men and horses; also General Finch's brigade, consisting of 252 men and horses, making in all 486 horses with their riders, and for which 48 flat boats will be necessary: when they are landed, the boats are to return and land the horses belonging to the artillery, amounting to 182, and 86 men; also those belonging to the staff of the army, about 120, with their keepers; also such a proportion of forage as shall be judged necessary. After this service is performed, Captain Stevenson's and Morrison's divisions will be employed in landing water and provisions, to be deposited in the situations pointed out by the Commissary-General. All the vessels not employed by Captain Larmour in the Ordnance department will be dedicated to this service, particularly for the conveyance of water from the fleet to the army, should they require it, which is likely to be the case.

When the whole army is disembarked, Captain Larmour's division, with the launches that land the guns, except such as may be ordered to act as gun-boats, are to be exclusively appropriated to land all the ordnance and stores, together with those belonging to the Engineers' department in this service. Captain Larmour will be assisted by Lieutenant Kemp, the agent for those departments.

See latter part of Section IV.

It will therefore fall directly under the direction of Captain Larmour to have proper wharfs erected for the stores being landed upon (applying to the Admiral for carpenters); that the boats are fitted for the reception of the heavy guns; slides provided to roll the guns out on; a proportion of 2-inch planks are to be taken in each boat, for the trucks or wheels of the guns to run on when landed; and afterwards to accompany the guns, to prevent their sinking in the sand, should it be judged necessary: purchases prepared for getting the guns up on the shore, anchors sunk in the sand in situations proper for hauling the boats up by, in the event of bad weather, and such further precautions as may be judged necessary: some decked vessels will be placed under his directions, for the conveying of such stores as are liable to receive injury from the weather, as well as for the transportation of fascines, palisades, &c., &c.

Captain Scott's division, after the last brigade is landed, will disembark the dismounted dragoons, in number about 751 men; also the pioneers of the army, nearly

400 men; after which, should it be necessary, they will assist in the same service as Captain Stevenson's division; and on these duties Captain Scott will call to his assistance Lieutenant Brown, Agent for Transports.

Captain Apthorpe will, after the troops are on shore, employ his division in landing the stores belonging to the general hospital; also those that appertain to Quarter-Master-General departments, and such others as do not fall under those heads already mentioned; but should those stores be soon landed, Captain Apthorpe will employ his boats on any other services where the demands are most urgent.

As it is quite impossible to foresee the different duties that must be performed by the boats of the fleet, and from the variety of situations I may be in, during the course of the intended service, it may not be in my power to give all the necessary orders; the Captains of the different divisions must therefore exercise their own judgments upon many occasions. I shall only recommend that where any service is demanded by the heads of departments, that the same be complied with; but on all occasions, those orders that come immediately from the Commander-in-Chief of the army, the Adjutant-General, or his deputy, Colonel Abercrombie, the Quarter-Master-General or his deputy, are to have the preference.

Care must be taken that the boats' crews are regularly relieved when the service will admit of it, in order to prevent sickness from over fatigue, or being too long exposed to the sun.

The boats' sails, when they have not awnings, are to be spread over them, when it can be done with convenience, both to afford shelter to the men, and to prevent the sun from rending the boats, which will be greatly assisted by their being frequently wetted, particularly in the evening, except when the men are forced to sleep in them, upon which occasion doing it in the day-time is to be preferred.

The flat boats are not to be employed on any duty where they are liable to injury, and the utmost care must be taken to keep them in constant repair; upon which account it is recommended that a carpenter shall be sent from each ship as one of her crew, being provided with a hammer, an assortment of nails and materials proper for stopping shot-holes,* or affording a temporary repair to the boat. These carpenters may be occasionally employed upon fitting wharfs, or other necessary services.

When any wounded men are brought down upon the beach, and a request shall be made for their being conveyed on board the hospital ships, the Captain of the division, to which such application shall be made, is to direct some of the boats under his orders to perform the service, and if necessary that the flat boats shall be removed, that the soldiers may be placed with convenience and ease to themselves, directing cutters or other boats to tow them. This service is particularly directed to the attention of Captain Apthorpe, whose division is attached to the Medical department.

Three days' provisions must be ready cooked for the crews of the boats, and each of the men provided with a blanket, one shirt, and a pair of trousers.

Every flat boat to have two spare oars, and a set of wooden thoels with grummets, in case the others should be lost or broken.

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* Thin sheet-lead, thin plank, sheathing-felt, oakum, tallow, &c., or (as in Sect. V.) "a seaman's jacket."—*Ed.*

SECTION VI. C.

*General Orders.**

Head-Quarters, Marmorice,
H. M. S. *Kent*, February 16th, 1801.

Such Officers' horses as were not embarked on the 14th instant will be on the beach ready for embarkation to-morrow morning, at 8 o'clock precisely. Officers will take notice, that after to-morrow no horses will be embarked.

The horses which have arrived for the cavalry since the last allotment are distributed as follows:

11th Light Dragoons	4	horses	On board No. 1.
Hompesch's	17	do.	
12th regiment	16	do.	On board No. 21.
26th do.	11	do.	

These horses will be on the beach ready for embarkation to-morrow morning, at 7 o'clock.

The horses will receive the following rations while on board ship, viz., 5 lbs. of barley, 5 lbs. of straw, and 3 gallons of water. As it has been impossible to supply all the horse vessels with weights and measures, the non-commissioned officers will use the Turkish steel-yards, which they will find on board, taking notice that the *Turkish ocque* is equal to 2 lbs. 11 oz. English; so that the rations for horses at present established will be two *ocques* of barley and three *ocques* of straw nearly.

Majors of Brigade are responsible that a copy of this Order, as well as of the 6th instant, is given to each of the non-commissioned officers in charge of the forage and provisions on board the different horse ships.

As nearly as circumstances will permit, the disembarkation of the army will take place in the following order:

1st. The Infantry of the Reserve, with 10 pieces of light artillery.
The Brigade of Guards.
The remainder of the first line, with 6 additional pieces of light artillery.

2nd. The Infantry of the second line.

3rd. The mounted detachments of Cavalry of the Reserve and Brigadier Finch's brigade.

4th. The dismounted part of the same brigade.

5th. The pioneers of the army, the horse detachment of the Royal Artillery, and such additional pieces of ordnance and ammunition as may be wanted.

When the troops are ordered to land, the men are to be put into the flat boats as expeditiously as possible, but without hurry or disorder; they are to sit down in the boats, and in rowing to the shore the strictest silence to be observed: *the troops are positively ordered not to load till formed on the beach;* the formation is to be effected as soon as possible; the men are to fall in, in line, opposite to where they land; nor is any individual or body of men, in conceiving themselves displaced, to attempt to regain their situation by closing to either flank, till ordered so to do by the General Officer on whom they depend, or the Senior Officer present on the spot.

The troops are to land with sixty rounds of ammunition and two spare flints per man; the ammunition which cannot be contained in the pouches to be carefully put in the packs. Three days' bread and three days' pork, ready cooked, is to be carried by officers and men; the same quantity is to be landed to the troops; it is

** Abridged.

not, however, to be delivered out, but carried in kegs, and put under charge of the Quarter-Master of each regiment, with a party sufficient for the purpose: each man will carry his canteen filled with water.

Three days' barley will be carried for the horses of the cavalry, and of the Staff and Field Officers.

The Staff and Field Officers must provide themselves with forage-sacks previous to the fleet sailing from this.

The men will carry their intrenching tools, and the proportion of necessaries specified in the Orders of 15th August last, viz., 2 shirts, 1 pair of shoes, 2 pair of socks or stockings, neatly made up in their packs or knapsacks, their camp kettles and blankets. Regiments having both blankets and great coats will leave the latter on board.

It is absolutely necessary that the Officers should bring on shore in the first instance such articles only as they can carry themselves. Officers' servants are not only on all occasions of service to be present under arms with the corps to which they belong; but they are to carry no more than any other soldier, and are to mount all pickets and guards with their masters.

The smallest number of bâtmen possible will be permitted: mounted Officers alone are entitled to them.

The music, drummers, and men least fit for actual service, are to be selected for all regimental duties not purely military; and Officers commanding corps will be held strictly responsible for their being at all times, and in every situation, in the most effective state.

A proportion of the general Hospital Staff must be attached in the first instance to each brigade, and will be allowed such orderlies as are absolutely necessary from the brigade. Regimental Surgeons are to be allowed one orderly each, to carry the field case of instruments.

The spare arms, tents, and horse appointments of the dismounted cavalry, and every article of spare baggage, are to be left in charge of a careful non-commissioned officer on board of each ship.

After the troops have landed, the sick of such regiments as are embarked in transports are to be collected into one of the vessels occupied by the corps, under the care of the Assistant Surgeon, who will, as soon as possible, report himself and the state of the men under his charge to the Inspector-General of Hospitals on board H. M. S. *Niger*. In case of there being only one Medical Officer present with any regiment thus situated, this duty must be assigned to a careful non-commissioned officer.

Regiments embarked in men-of-war will leave the sick under the care of the Surgeon of the ship, who will be entitled to the allowance established in such cases. If necessary, a small proportion of orderly men may be left with the sick, to be selected from the convalescent men: regiments that have women will employ nurses in lieu of orderly men. The women are positively prohibited from landing on any pretence whatever, until the Commanding Officers of corps have obtained the Commander-in-Chief's express permission for that purpose.

Detailed instructions relative to the Artillery, Engineers, and Commissariat, will be communicated to the respective heads of those departments.

SECTION VII.

On referring this important Article to a distinguished Naval Officer lately employed in the Chinese seas, he declined contributing the necessary information on

account of the impossibility of defining precisely what is to be done in regard to embarking and disembarking troops under fire,—these operations depending upon local circumstances; and because that, before orders can be issued, a careful reconnoissance must be made of the place proposed for the point of embarkation and disembarkation,—how it is protected,—how near it can be approached with vessels of light draft of water to scour the beach and cover the boats,—what description of boats are at command,—the number of men to be landed and taken off, &c.*

But assuming that these preliminary questions are provided for, the details and precise arrangements for the embarkation and disembarkation of *troops and stores* are desirable; therefore, in order to give every information possible, the best authorities attainable have been selected, as given in the preceding Sections.

For ordinary circumstances, and every-day occurrence to British soldiers in their tour of foreign and colonial service, the Queen's Regulations should be consulted, commencing at page 325 and ending at 369, third edition.

The introduction of steam to maritime war affords facilities of transport, and the means of covering a landing or re-embarkation not available before; but these additional means do not give the actual operations any greater facilities than before, as the men and stores are still to be placed in boats adapted to the local circumstances.

For distant operations, the long boat of the transport and the launch, barge, and pinnace, are the only resources which have hitherto served the purpose; and flat-bottom and other boats constructed expressly for the landing of troops are difficult to carry, and rarely found at the point of debarkation.

The British soldier, after a few weeks afloat, acquires a certain degree of handiness, and what is termed his 'sea legs;' he will then profit by the hints offered in Section IV. of this Article, written by Captain Rea, of the Royal Marines.

The landing in Egypt in 1801 is given in Section VI., as example of a debarkation of a large force, as extracted from Sir Robert Wilson's 'History of the British Expedition,' fourth edition. The force landed was probably the largest (5000 men) ever

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* The following memoranda for reconnoitring previous, or for report subsequent, to a landing may be useful and acceptable.

CÔTES.

" La nature des côtes, bordées de dunes, couvertes de rochers plats qui rendent leur abord plus ou moins dangereux; hérissées de falaises qui en interdisent absolument l'accès—les parties développées et découvertes propres aux descentes—les parties rentrantes offrant des anses et des ports—les pointes et les caps propres aux forts, aux batteries, qui pourront défendre les points accessibles—les îles adjacentes servant d'ouvrages avancés qui forment des barrières aux tentatives de l'ennemi—les laisses—les anses—les baies—les rades—les ports; la nature des vents qui sont nécessaires pour l'entrée et pour la sortie de ces ports, dont il faut indiquer les avantages et les inconvéniens—les différentes batteries établies pour la défense des mouillages, des passes—les retranchemens, les épaulemens pratiqués dans les parties où l'on peut tenter les descentes—les camps, les postes qui doivent couvrir les principaux établissemens et l'intérieur du pays—exposer tout ce qui caractérise les endroits accessibles; les dangers qu'on aura à courir; les obstacles à surmonter; les moyens de les augmenter, les temps des marées plus ou moins favorables à l'approche des endroits. Indiquer les lieux donnant des positions plus avantageuses aux moyens de défense et aux points à défendre—l'état actuel des forts qui protégent la côte; des batteries; des corps-de-garde et de toutes les pièces d'artillerie qui peuvent s'y trouver—analyser les systèmes de défense donnés; les améliorer, en faire un nouveau—calculer les forces que peuvent fournir, dans un moment de surprise, les canonniers gardes—côtes, en attendant que les troupes réglées de tels et tels lieux puissent arriver aux points attaqués.—S'il est des rivières qui aient leur embouchure sur ces côtes; les marées apportent des variations sur leur passage; il faut rendre un compte exact de cette influence."—*Aide-Mémoire à l'usage des Officiers d'Artillerie de France.* Tome second, 5th ed., p. 1152.

thrown on shore at one time, and the whole of the arrangements appear as perfect as they were successful, and serve as a beautiful study for similar operations.

In considering the important points embraced by this subject, and in recapitulating the Sections of this Article, which comprise, as regards *Embarkation,*

First, the deliberate and careful stowing the Artillery, Engineer, and other stores, to be placed in the vessels in the order of the probable wants, and so as easily to be got at; as explained in Sections I. and II.;—

Secondly, the embarkation of the horses and troops;—

Lastly, the economy and management of the whole afloat, which are especially provided and explained in the Queen's Regulations;—

In the *Disembarkation,* the above 'Secondly' become the first for consideration: the men placed in boats, and the horses swum on shore, with a few pieces of light artillery, dragged on in the first instance into action by seamen: otherwise the first operation in embarking is the last in the disembarkation: the final one will, of course, depend upon the Objective Points of the expedition to be attained.

G. G. L.

DISINFECTION.—*Vide* 'Sanatory Precautions.'

DIVING BELL.—~~Vide vol. ii.~~

DIVING DRESS AND APPARATUS.*

For the removal of wrecks, shoals, enlarging entrances to harbours,† making submarine surveys, &c., where so much of the diver's success depends upon his being able to extend his operations over a large space of ground, the Diving Dress possesses many advantages over the Diving Bell, as the latter, although very useful in building under water, affords so limited a space for working that it much impedes the operations of a diver when employed on either of the above-named objects. Thus, for general purposes, the diving dress is preferred to the bell, and it has been a desideratum to ascertain the best form to be given to it, so as to preserve the health, and endanger as little as possible the safety, of the men employed.

Mr. Deane appears to have been the first person known to have used the diving dress, or at least to have turned it to any practical utility. His apparatus is exceedingly simple, and is usually styled the 'Open Dress,' on account of the metal helmet (which covers the head and breast of the diver) being separate and unattached to the lower part or body of the dress. The latter is made of stout Macintosh cloth, and forms a complete water-proof covering to the body from the feet to the neck: here, as well as at the ends of the sleeves, there are openings left sufficiently large for drawing the dress over the person, and for passing the hands through, which must be left exposed to enable the diver to work properly: these ends are tightened round the wrists by linen wrappers, while the upper opening is plaited, and loosely drawn in round the neck, and confined there by a handkerchief or band. The metal helmet, with a loose canvass jacket attached, drops

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* By Capt. Hutchinson, R. E.

† Helmet divers have been recently employed in enlarging the entrance to St. George's harbour, Bermuda.

down over the head upon the diver's shoulders, being prevented from coming off by weights suspended from it, resting against his breast and back. The helmet on this principle becomes a small portable diving bell carried about by the diver while at the bottom, and the circumambient water is at the same time prevented, by the dress, from getting to his person. An air-pipe leads from the back of the helmet to the surface, and when a proper supply of air is delivered from the air-pump above, the water will be perfectly excluded from the helmet down to about the level of the neck: the collar of the dress should come up as high as the diver's ears, so that any water accidentally rising higher, from air imperfectly supplied or other causes, may be prevented, as much as possible, from flowing over the collar and wetting his person,—a circumstance attended with most injurious effects to health, and necessarily retarding the operations. It should be remarked, that with Mr. Deane's apparatus the diver must always keep his head as nearly as possible upright; in stooping or lying down with the head out of that position, the water will have a tendency to rise in the helmet and flow over the collar; and if by accident he should fall down head foremost, or become entangled with the head downwards, he would certainly be drowned, unless speedily extricated and hauled up. This is a great inconvenience, as most divers prefer the stooping or creeping posture while working to any other, and it becomes troublesome and painful to keep the head erect while the rest of the body is not so. On the other hand, divers remark that the air they breathe is much purer while working in this dress than in what is called the 'Tight or Close Dress,' which will presently be described, on account of the freedom with which the waste or foul air can escape from a helmet open at the bottom.

The inconvenience, and even danger, attending the use of the open dress, which is particularly felt by inexperienced divers, has led to several modifications being made in it by ingenious men, with the view of connecting the helmet and lower part of the dress so as to form one complete water-tight covering which shall enable the diver to work in any position without being subject to the risk and inconvenience of water entering from without: among these may be mentioned Messrs. Bethell, Fraser, Sadler, and particularly Mr. Siebe, of Denmark Street, Soho, whose pattern is perhaps the most perfect yet produced. Mr. Siebe, by the recommendation of Major-General Pasley, was employed by the Admiralty in making the greater part of the dresses and apparatus required for the removal of the wreck of the *Royal George* at Spithead, and he also supplies those required for their Naval Establishments, vessels of war, &c. His latest improved construction on the water-tight principle will now be described.

The dress represented in Plate I. fig. 1, may be considered as divided into two parts. The helmet or upper part (unyielding) is formed of metal, copper, tinned over, and covers the head and breast; the lower part (flexible and yielding), covering the legs, body, and arms, is formed of Macintosh cloth, with sheet India-rubber outside, which is found to preserve it from rotting and to keep the dress much drier than when the cloth is exposed: a leather band, fixed round the top of the lower part and pierced with twelve holes at equal distances from each other, fits on to the lower edge of the helmet, where there are twelve projecting brass screws, so placed as to fit into the holes in the band; they are screwed together with thumb-screws. The joint is made water-tight by the leather band and by a species of thin leather washer fixed round the lower edge of the helmet: as in the common diving dress, there is an internal collar coming up to the diver's ears, and tied round the neck with a handkerchief, so that, should any small quantity of water penetrate at this joint, which will occasionally work in through the screw holes, it will be collected in the cavity between the collar and helmet, and may be shaken out by the diver on his ascending and having his helmet taken off.

Plate I. figs. 3, 4. The fresh air is forced in by a pipe screwed on to the back of the helmet, and the foul or waste air escapes by an aperture near it, covered by a valve which is so constructed as to be kept open by the force of the waste air rushing out so long as it is superior to the pressure of the surrounding water; but if it ceases to be so, the valve closes by the pressure of an elastic wire spring which has been previously collapsed by the pressure from within, and thus the water is always excluded. The fresh air in Mr. Siebe's plan is not suffered to enter the helmet at one internal orifice, but is divided after leaving the air-pipe into three or four branches, formed in the helmet so as not to throw too strong a stream of air upon the diver's head. Other makers prefer having a single orifice for the entrance of the fresh air, situated immediately above the centre lens or glass of the helmet, with the idea of dispersing the vapour which has a tendency to collect upon the inside of the glass and to render it dim. The helmet has three glasses or lenses, the two side ones oval, the centre circular,—which is made to unscrew, so that if the diver should find it necessary to come up for fresh air or to communicate any thing for which he finds his signals insufficient, he may merely have this centre glass removed and replaced after making his communication.

Mr. Siebe has contrived an ingenious arrangement by which the diver may be relieved of the pressure of his weights and helmet in about half a minute after he has come up from the bottom; so that if he has slung some heavy mass below, either a gun or a large piece of timber, in working against a wreck, or wishes to be relieved from their weight from a feeling of fatigue, it may be done without the necessity of Plate I. figs. 5, 6. unscrewing the whole dress. This arrangement is effected by making the upper part or head of the helmet to screw on and off the lower part or gorget. The lower part of the head and upper part of the gorget being circles of 9 inches diameter, their circumferences on the interior of the one and exterior of the other are divided into eight equal parts; every alternate division is cut with a screw, the intermediate ones being left with a smooth surface: thus the head of the helmet being dropped upon the gorget in such a position that the divisions cut with screws of the former may be in contact with the plain surfaces of the latter, on turning the helmet the $\frac{1}{8}$th part of the circle, that is, about $3\frac{1}{2}$ inches, both the surfaces with screws will fit into each other and fix the two parts closely together, a leather collar between making the whole water-tight. In this manner, with the centre lens to unscrew for the mere purpose of giving the diver air or an opportunity of explaining any thing, and with the upper part of the helmet to take off to relieve him of its weight if he should have to remain above water for any length of time before making another descent, the helmet is as complete and serviceable as can be desired.

Plate I. figs. 1, 2. Two brass eyes are fixed, one on each side of the lower circle of the head of the helmet, through which are passed the cords for hanging lead weights (about 40 lbs. each), one of which is suspended at the diver's back, the other in front of his breast: the head of the helmet is thus additionally secured and pressed down upon the gorget.

As the diver's hands must be exposed to enable him to work properly at the bottom, where he has generally to feel his way from the water being too thick and obscure to allow him to distinguish surrounding objects, the openings left at the ends of the sleeves must be very carefully closed over the wrists by plaiting those ends and passing linen wrappers tightly round,—soft bandages having previously been placed underneath to prevent the skin from chafing: this must be carefully attended to, otherwise the water would be sure to penetrate: the pressure will cause at first slight pain and numbness in the hands, but the sensation will go off on getting into the water.

To guard against the effects of damp and cold striking through the dress, the diver must be well clothed in flannel or woollen dresses: he generally puts on two suits, each consisting of a pair of drawers, stockings, and a Guernsey frock; these must be well dried, and aired on being taken off: a constant change is necessary, so that every diver should have about six suits in wear. At Spithead the regulations as to drying were strictly enforced; a cabin was set apart in the vessel on board of which the men were quartered, as a drying-room, with a stove in the centre and rails all round for hanging the dresses on; the divers' attendants received them as they were taken off, took them to the drying-room, and supplied fresh ones before the ensuing tide: in this way, the divers were always provided with warm comfortable garments, but notwithstanding these precautions many were subject to violent attacks of rheumatism.

Every diver should likewise be provided with three good serviceable waterproof dresses to be worn in turns, so that he may be enabled to change them continually, if required: the dresses not in use may be kept exposed to a *gentle* heat, so as to dry them thoroughly, but they should on no account be hung up to dry in a *hot* sun, as the India-rubber would thereby be melted.

The diver's feet are protected by heavy shoes with lead soles, weighing about 24 lbs.; these, together with a pair of woollen stockings, are worn over the dress; the stockings being first drawn on, prevent the shoes from cutting it. The feet of the dress should be soled with leather over the India-rubber, to prevent its being cut by small gravel working in over the shoes. The dress is also protected from rubbing or chafing by a canvass jacket and trousers worn over so as entirely to cover it.

In descending to a wreck, the diver goes down a rope ladder, which is made fast to the deck of the vessel above, and weighted by a 3-cwt. pig of ballast below; the rungs should be about 18 inches long from end to end, or 15 inches between the sides, which are formed of $2\frac{1}{2}$-inch rope; they should be 15 inches apart under water, and above water this space should diminish to a foot, as the great weight of the dress and appendages will make it laborious for the diver to step higher when he is not buoyed up by the water. A breast or life-line completes the diver's equipment: it should be either patent netted line or 2-inch rope, laid what is technically called the 'reverse way,' so that it may not have a tendency to twist when under water, which should be avoided as much as possible.

This line is passed round the body under the arms, then leads through a knot in front of the breast to the surface, where a careful man has charge of it, whose duty it is to attend to all signals made by the diver, consisting of a certain number of pulls on it for any communication he may wish to make, which he generally arranges with his assistant before going down: these signals are very simple, and have generally reference to the working of the crabs or capstans, while the diver is slinging any thing below: thus, 1 pull signifies 'Heave round,'—2 pulls, 'Hold on,'—3 pulls, 'Lower the large rope,' (called by divers 'bull rope,')—4 pulls, 'Lower a second rope;' a number of pulls signify that the diver wishes to come up, &c., &c. While the diver is at the bottom, another careful man is stationed at the air-pipe, which leads from the back of the helmet round under the left arm to the front, and then to the surface; he attends to any signals that may be made on it for more or less air, and sees that it is carefully coiled up as the diver ascends. Neither the pipe nor line should ever be allowed to become slack, but a gentle strain should be kept on each.

OF THE AIR-PUMPS.

Plates III. IV. The best kind of diving air-pumps used for helmet divers when working in depths

not exceeding 13 to 15 fathoms, are composed of three brass cylinders, 9 inches high and 4 inches interior diameter, with pistons giving a 7-inch stroke, attached to a horizontal axle with three cranks forming angles of 120° with each other: the axle is worked by two handles at the ends, with two men to each: the air is thrown from each cylinder in succession on the downward strokes of the pistons into a common barrel or reservoir below the cylinders, thence into the air-pipe, which is screwed on to one end of it. There are valves to the pistons and cylinders, which are depressed on each downward stroke of the former, and allow the air to enter the barrel; they close again with considerable force on the pistons being raised, and prevent the air from returning. Fresh air is admitted from the exterior by small circular orifices left above the pistons and immediately below their rods; thus there is a constant unintermitting stream of air forced down to the diver, which, by the old plan of a single barrel and piston worked by levers, was not the case, as on the rise of the piston the current was interrupted until its next descent.

This plan of having three cylinders has been generally adopted by most makers, but until the year 1840 it had one essential defect, which was caused by the air becoming heated by the friction of the pistons within the cylinders; it was thus sent down to the diver hot and impure; constant repairs were required, and a pump of larger dimensions than necessary had to be used: to remedy this defect, Mr. Siebe has introduced an important improvement in his air-pumps by enclosing the cylinders in a cold water cistern; this is continually filled by a suction-pump drawing up water from the sea, or wherever the operations may be going on, its piston being worked at the same time as those of the air-pump, by means of an eccentric circle attached to the common axle and revolving with it: a waste-pipe leads the water away after it has reached a certain level; thus there is a constant stream of cold water around the cylinders, which has the desired effect of keeping them perfectly cool and of sending down pure and cool air to the diver. The whole detail of construction and workmanship of Mr. Siebe's pumps is very perfect, and they seldom or ever fail, excepting from some trifling cause which may readily be rectified. At a depth of 90 feet under water, the diver has to sustain a pressure of about three atmospheres, which must be counteracted and the equilibrium preserved by throwing air of corresponding density into the helmet. An air-pump of the above dimensions will not be more than sufficiently powerful to keep up a steady supply of air thus condensed during the whole time the diver is at the bottom, where he sometimes remains from two to three hours. As the operation of pumping at this depth for so long a time becomes very laborious, it is necessary to have two, or even three, reliefs of men at the pumps to change about every ten minutes: those not actually pumping will be available for the other duties of working the crabs and capstans, attending to the gear, &c. At Spithead we found that two and a half reliefs, or ten men at each pump, was the minimum that could be employed; thus each diver will require at least twelve men, including his two assistants, and fifteen should be allowed, so as to give some spare men for boats and other duties, for which on such operations they will always be required.

The air-pump is fixed into a box measuring 2 feet square and standing 3′ 6″ high, so that there may be a height of 3 feet to the centre of the handles, which is the best height for working them: the box has a lid to close it, but this should never be shut down, if it can be avoided, while the air-pump is being worked, as the air will then be too much confined: there is a fly-wheel on the axle, 3 feet in diameter.

In the Levant, diving has been carried on in far greater depths than any which have been attempted in England. During a naval engagement at Tchesme, near the island of Scio, between the Turks and Russians, about seventy years ago, the Turkish

and Russian flag-ships were both sunk, and it was supposed with a considerable quantity of treasure on board: many attempts have been made to recover it, and the depth being 30 fathoms, the enterprise was attended with much difficulty and some danger: a pump for such an operation is required to be much more powerful than the one already described, and it will be more economical to work it by a small steam engine fixed on the deck of the vessel above, than in any other way. The one used for the operations* in the Levant contained three cylinders 5¼ inches diameter, with pistons giving a 32-inch stroke. The axle made twenty-two revolutions per minute, and was worked by a steam engine of 10 horse-power. With these powerful machines the diving was performed in comparative safety, but I have been informed that the divers had to be relieved every half hour, that they were then apparently unconscious of the time that had elapsed, and while below had lost all recollection of every thing excepting the object for which they were sent down. I do not find, however, that they have been permanently injured by so perilous an occupation, but are generally stout, robust men, whose frames are probably peculiarly constituted to enable them to resist the effects of protracted submersion at such great depths.

OF THE AIR-PIPES.

The air-pipes are usually formed of an outer casing of solid sheet India-rubber, about ½ inch thick, stiffened internally with spiral wire, the bore or opening for air being left about ½ inch diameter in the clear: thus the total diameter of the pipe on the outside will be from 1½ inch to 1¾ inch; it must be entirely covered with canvass to protect the India-rubber from friction in descending to the bottom; the part remaining above water should be carefully coiled away in a tub, and any portion which may have to lie along the deck of the vessel or on the ground should also be covered by lengths of wooden trough, about 2½ inches or 3 inches square, to prevent the workmen from treading on it. Too many precautions cannot be taken to keep the air-pipe from being injured, as upon this the safety of the diver in a great measure depends. The wire used for stiffening it should be of copper or gun-metal. Pipes of inferior manufacture are sometimes stiffened with iron wire tinned over, but these should be rejected as unfit for use, for the moisture will cause the wire to rust, which will then soon become broken, and by degrees cut through the India-rubber: a fracture may thus be caused in the pipe, which would be attended with serious consequences to the diver, if it occurred while he was at the bottom; for as in such a case the air thrown into the pipe would escape before it reached him, the equilibrium of pressure would be destroyed, and the surrounding water would act upon his person with a pressure due to the depth at which he might happen to be working, or at a depth of 90 feet, to three atmospheres.

Some instances of this have actually occurred where the body has been as it were so squeezed and compressed by the weight of water, that the blood has been forcibly driven into the vessels of the head and neck, causing a state resembling asphyxia, and disabling the diver for a month or six weeks: fortunately none of these cases, though very alarming, have terminated fatally.† To guard against such frightful accidents, every diving apparatus should be provided with a safety-valve opening downwards, to

* These operations were conducted by Mr. Love, a very able submarine Engineer, who has been employed at Gibraltar in getting up a portion of the American frigate *Missouri*, burned in that bay in the year 1843.

† Two privates of the Royal Sappers and Miners suffered in this manner in the years 1841 and 1842, while employed under Major-General Pasley as divers over the wreck of the *Royal George*, at Spithead. When got up on deck they were insensible; blood was running from their ears, noses, and mouth; their faces and necks were swollen and discoloured, and a perfect mass of lividity.

be screwed on between the end of the pipe and the helmet. The air on being forced in from the pump opens the valve and allows it to pass into the dress; but on this pressure being removed, the valve closes and prevents any of the air already in the dress from escaping back through the pipe, and the quantity of air thus enclosed within the dress would be quite sufficient to support life for several minutes, or for a much longer time than would be required to haul a man up from the bottom.

The air-pipes are made in lengths of from 30 to 40 feet, with union screw joints to each, so that they may be screwed up without twisting. They should be proved from time to time to ascertain that they are perfect throughout, by closing one end and forcing in air from the other by the air-pump to any degree of condensation that may be considered necessary, which may be ascertained by a mercurial guage fitted to the pump.

It should be remarked that diving operations may be carried on at sea during half a gale of wind, for when about 6 feet below the surface divers feel little or nothing of the motion of the waves above them; the principal inconvenience they have to sustain is the motion of the vessel above, which sometimes prevents their signals from being properly delivered, and jerks their ladder up and down.

The following is a list of the articles composing Mr. Siebe's diving apparatus:

1. A three-throw forcing air-pump, with apparatus for keeping the cylinders cool, and gear-work in a strong wooden chest, with iron fly-wheel, wrenches, joints, &c., complete.
2. Improved diving helmet, with strong plate glasses and brass frames; the front lens to unscrew and head to screw off; a brass collar and screws with which the dress is fastened water-tight.
3. Three patent India-rubber dresses to fit the helmet.
4. 150 feet of patent India-rubber pipe, ½-inch bore; solid sheet of India-rubber inside and outside, with brass screwed joints and two extra joints.
5. Six Guernsey frocks, 6 pairs of drawers, 6 pairs of stockings, 1 canvass jacket, 1 pair of canvass over-alls, 1 pair of shoes with lead soles.
6. Two lead weights, 1 chest for clothes, 1 basket for helmet, 1 knife with leather case and strop, 2 worsted caps, and 2 handkerchiefs, a patent life or breast line.

Price of the above, £160.

Weight of diving apparatus worn by a diver:

		lbs.
Helmet and gorget		23
Lead weights	front	43
	back	40
Shoes		24
Flannels		10½
India-rubber and canvass dress		20
Weight borne by a diver		160½

With respect to the pay of the divers,—

At Spithead the military divers of the Royal and E. I. Company's Sappers and Miners were rated in three classes, according to their skill and ability.

	s.	d.	
The 1st class received	2	0	per tide.
2nd "	1	9	"
3rd "	1	6	"

The number of tides per day varied from 2 to 3, and their average time of working was 2 hours.

Thus, taking one day with another, the divers would receive per day as follows:

	s.	*d.*
1st class	5	0
2nd	4	4
3rd	3	9

And where there is no tide-work, as in the Mediterranean, this would be a good rate of *daily* pay for *military* divers: civilian divers, however, would expect at least double this rate, or even more; but volunteers may always be found among soldiers, who will become sufficiently expert in the course of a few weeks.

N.B. The above rates are exclusive of their military pay or 'Subsistence.'

References to Plates.

Plate I.

Fig. 1. The diver in his dress, supposed to be at the bottom of the sea.

A. Air-pipe, screwed on to a nozzle at the back of helmet, confined by a belt round the waist, and led up under the left arm to the surface.

B. Breast or life-line passed under the arms, partly concealed by W, the front weight of about 43 lbs., with a similar one at the back.

K. Knife in waist belt, used for cutting away any thing with which the diver may become entangled.

L. Ladder line, to lead the diver back to his ladder after having travelled over the space allowed by its length.

P. Pricker, about 4 feet long, for probing or feeling in mud or soft ground.

S. Shoes with lead soles, weighing 12 lbs. each.

Fig. 2. Front elevation of helmet, with the upper part screwed to the lower, shewing the centre circular lens, to unscrew when required.

Fig. 3. Back elevation of ditto, shewing the nozzle for screwing the air-pipe, and the escape-valve for foul air.

Fig. 4. Section through the helmet, shewing the branches for the introduction of fresh air, the orifice for the escape of foul air, and the screw joint for connecting the upper and lower part.

Figs. 5 and 6. Plans shewing the alternate screw joint of connection.

Plate II.

Fig. 7. Side elevation of helmet.

Fig. 8. Plan of the lower part of helmet inverted, shewing the pads for the shoulders, and projecting screws.

Fig. 9. Plan of the top of the escape-valve, with the orifice for inserting the pin and cover, shewn in figs. 12 and 13.

Fig. 10. Side elevation of escape-valve, shewing the circular apertures in the cover for the escape of the foul air.

Fig. 11. Section through the seat of escape-valve, shewing the perforated cover screwed down.

Figs. 12 and 13. Shewing the section and plan of pin and cover of escape-valve, with the spiral spring of brass wire lying on the cover.

Fig. 14. Thumb-screw and plate for screwing up the lower part of the dress.

Fig. 1.

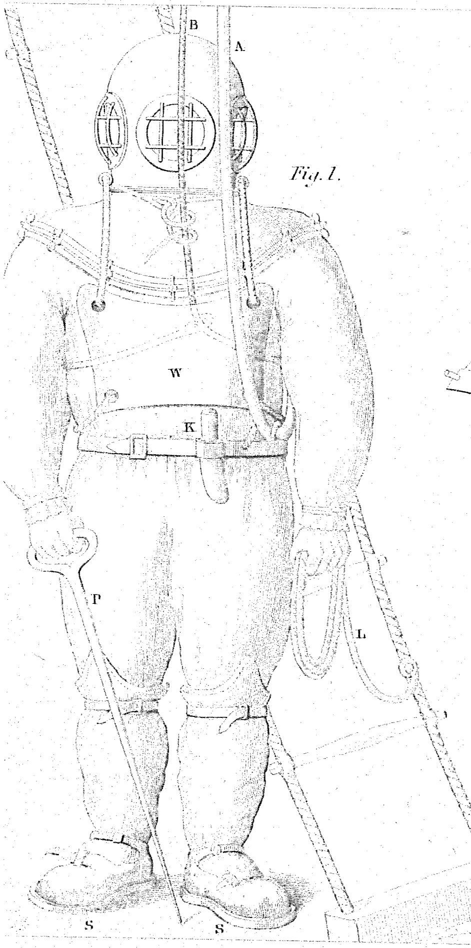


Fig. 2.

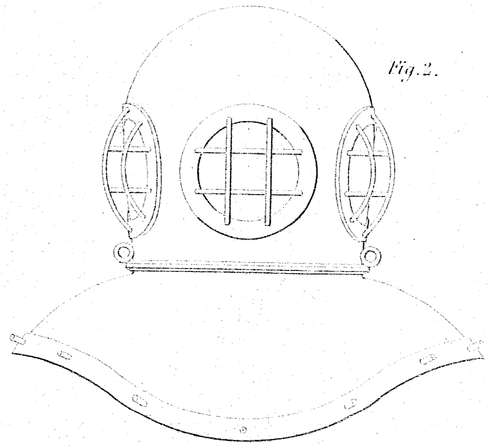


Fig. 3.

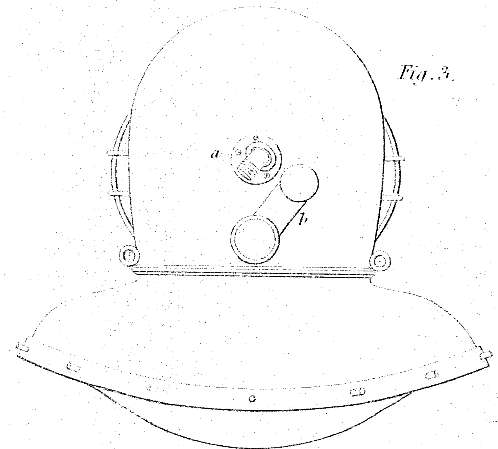


Fig. 4.
Section of Figs 2.3.5.6.

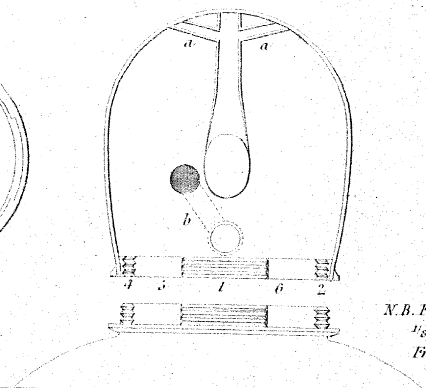


Fig. 5.

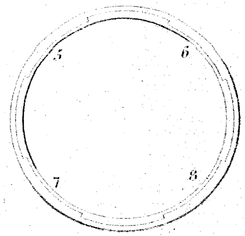
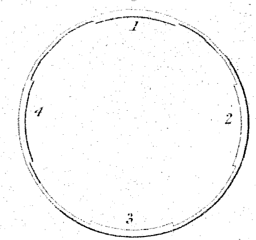


Fig. 6.



N.B. Figures from 2 to 8 are on a scale of 1/8 Inch to a Foot
From 9 to 14 are 1/2 full size

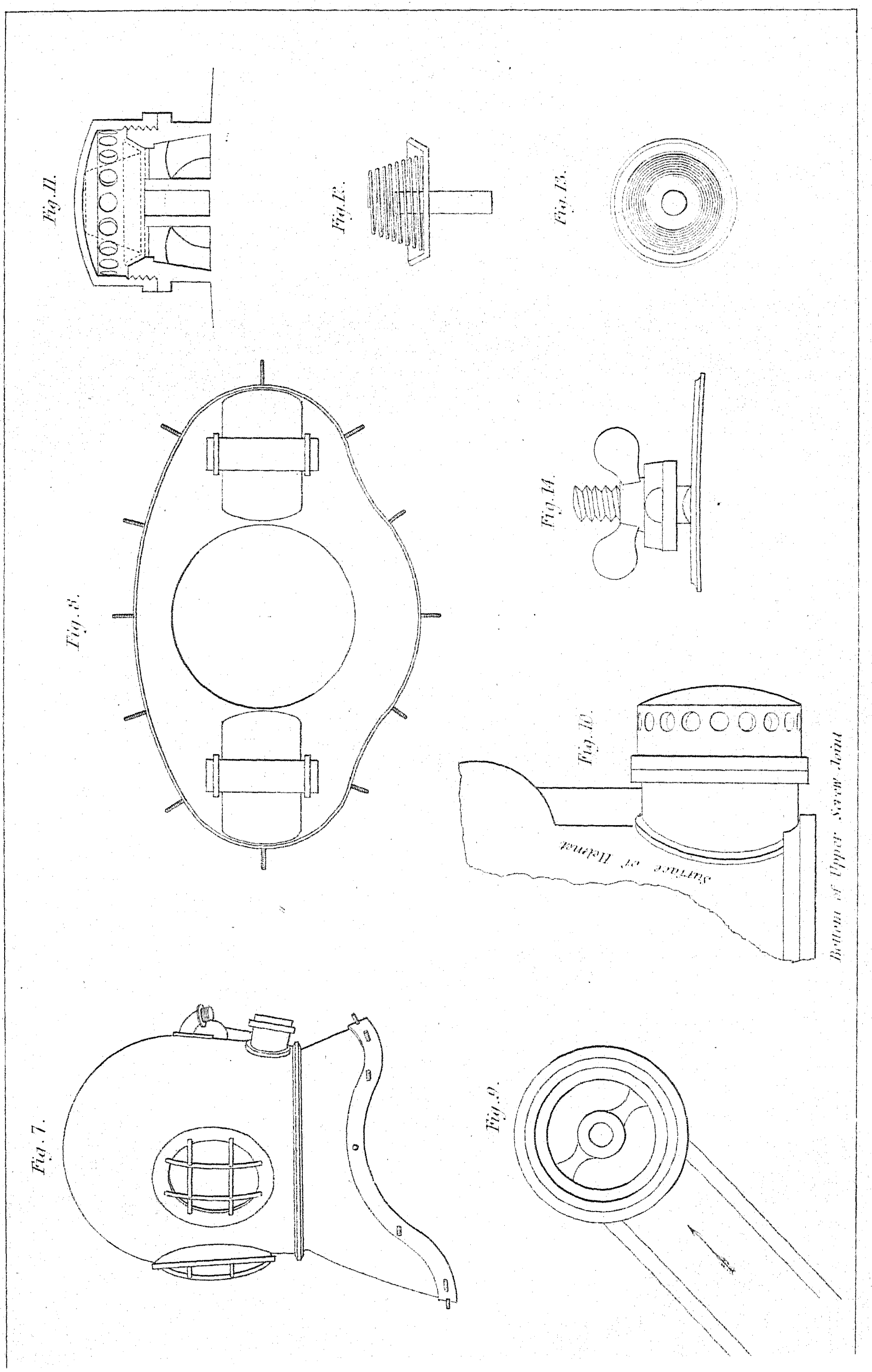
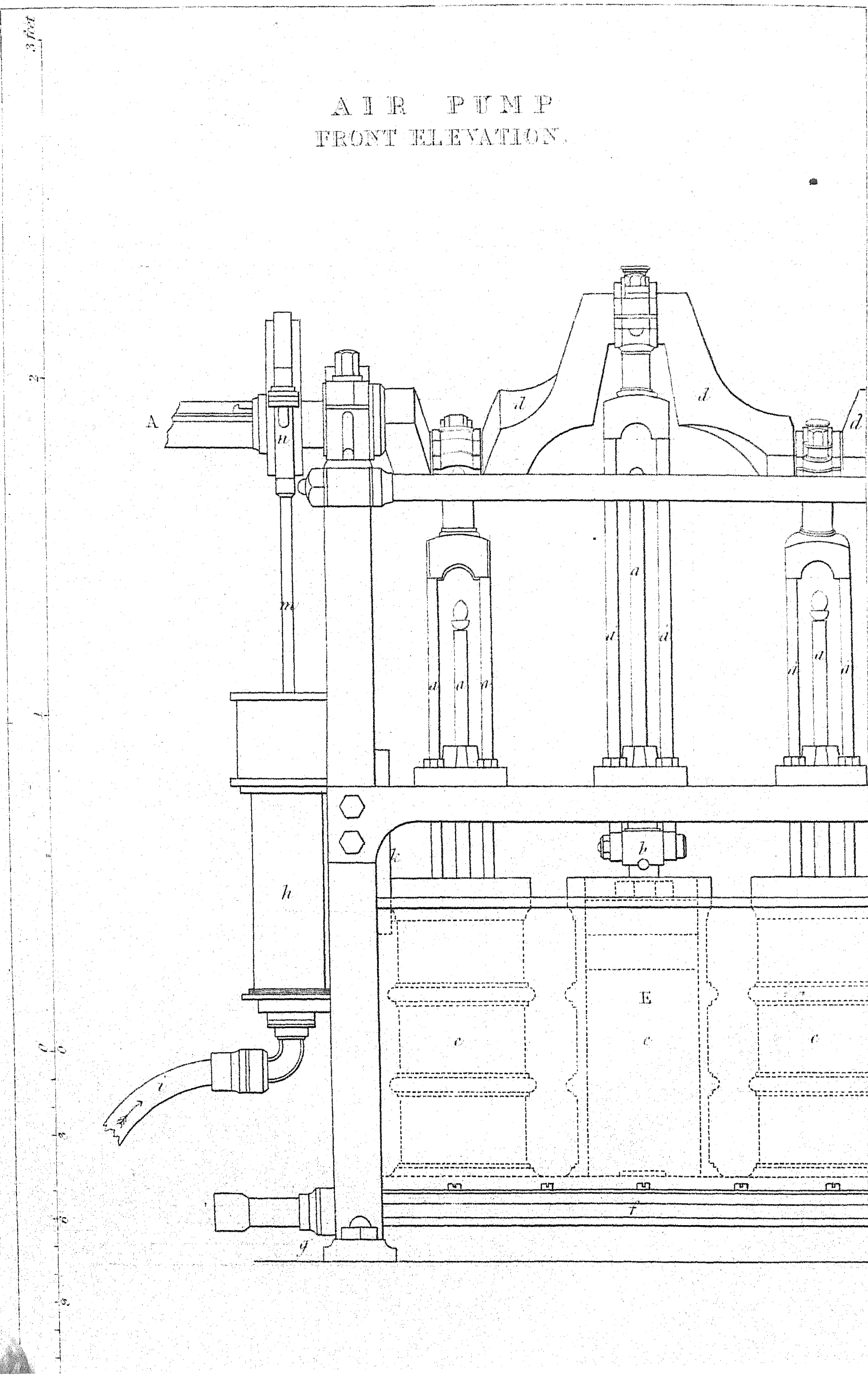
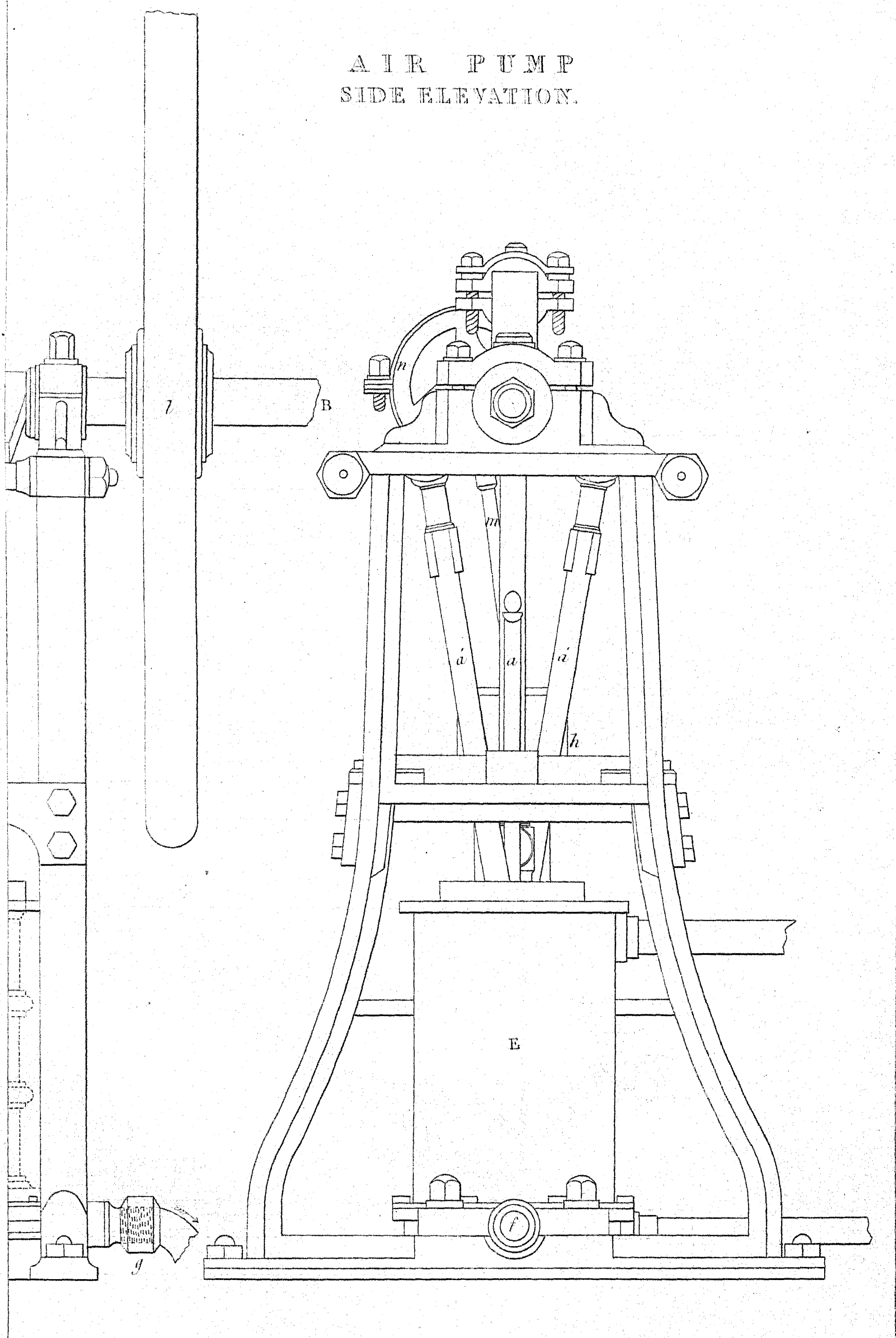


Fig. 11.
Fig. 12.
Fig. 13.
Fig. 8.
Fig. 14.
Fig. 10.
Surface of Helmet
Bottom of Upper Screw Joint
Fig. 7.
Fig. 9.

AIR PUMP
FRONT ELEVATION.



AIR PUMP
SIDE ELEVATION.



DETAILS OF AIR PUMP, CYLINDER & PISTON.

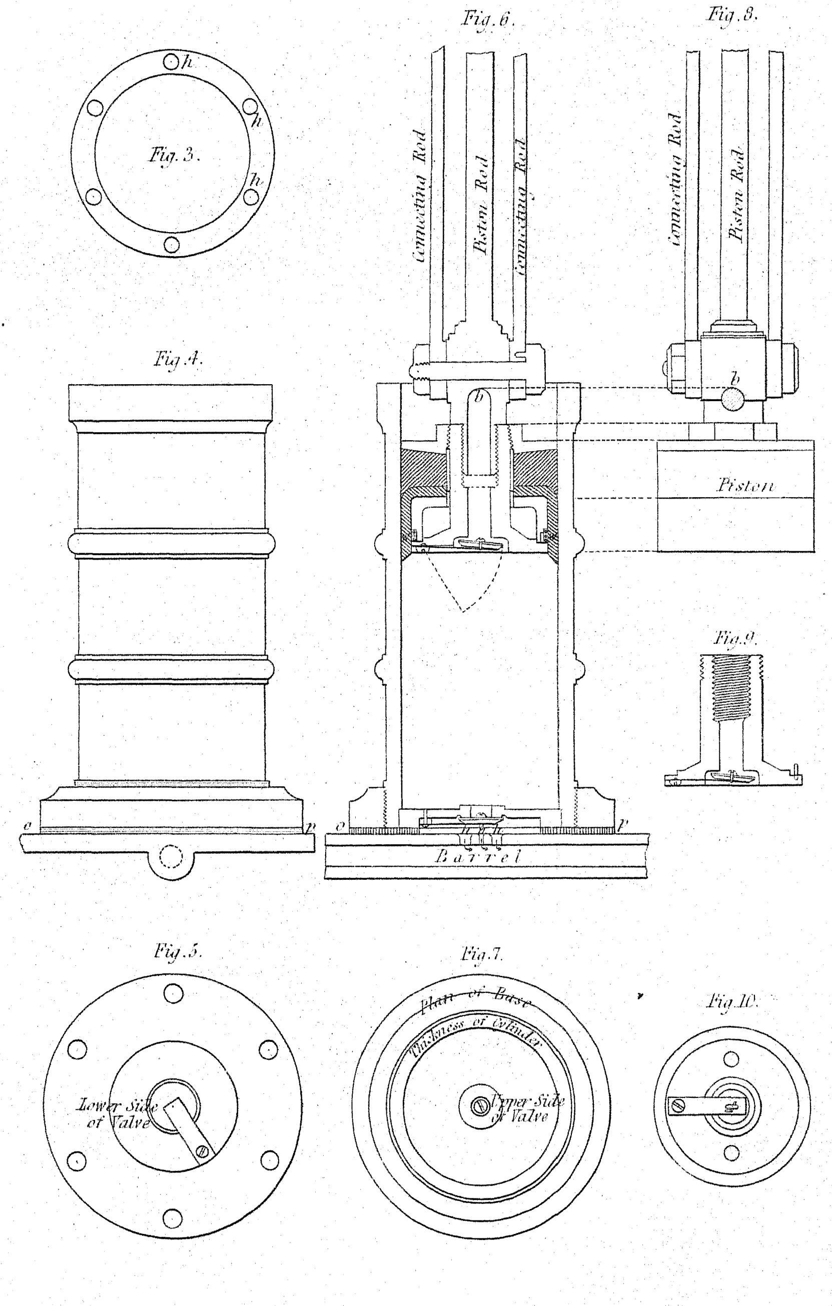


Plate III.

Figs. 1 and 2. Front and side elevations of air-pump.

a, a, a. The three piston-rods, successively raised and depressed by the revolution of the cranks, *d, d, d,* on the horizontal axle, A B. The centre piston, being raised to the top of its cylinder, shews the circular orifice, *b*, for the entrance of fresh air.

a′, a′, a′. Connecting rods.

c, c, c. The brass cylinders within the copper chamber, E.

f. The barrel for receiving the condensed air from the cylinders.

g. Nozzle at end of ditto, for screwing on the end of the air-pipe, the other end being fixed to the diver's helmet.

h. Suction-pump for drawing up cold water from the sea by the flexible pipe, *i*; the water is discharged into the copper chamber, E, by the metal pipe, *k*; vertical motion is communicated to the pump-rod, *m*, by the eccentric circle, *n*.

l. Fly-wheel at end of axle.

Plate IV.

Fig. 3. Plan of top of cylinder. The circular holes are for fixing a screw-wrench to screw the cylinder to its bed.

Fig. 4. Side elevation of brass cylinder. *o p* represents a leather washer, upon which the cylinder is screwed, to prevent the escape of the condensed air.

Fig. 5. Plan of under side of cylinder, shewing the valve.

Fig. 6. Section through cylinder and part of barrel, with the piston drawn up, shewing its valve, and the valve attached to the bottom of cylinder. *h.* Orifice and tube for the entrance of fresh air. *h, h, h.* Orifices below for the passage of condensed air into the barrel. This section represents the mode of screwing the piston-rod and piston to each other, and of securing the pieces of leather of which the piston is formed. *w, w.* Section of a circular wire spring which forces the under leather of the piston against the cylinder.

Fig. 7. Plan or horizontal section through the cylinder, shewing the upper side of lower valve.

Fig. 8. Side elevation of piston, and part of rods.

Fig. 9. Section through the metallic (brass) part of piston, with the pieces of leather, composing it, removed: the inner screw receives the piston-rod; the outer one is screwed into a brass cap or plate forming the top of the piston.

Fig. 10. Plan of the lower part of the piston, shewing the under side of valve.

DRAINING may be generally considered thus: with reference to—

A. Military purposes, B. Sanatory do. C. Economic do.	as the process of carrying off water as expeditiously as possible; in opposition to arrangements for irrigation and to dams, of which the object is to *retain* water and all control over its application.—See 'Dam.'

These may be further subdivided thus:

A. *a.* Draining an inundation, lake, &c.
„ *b.* Diverting the course of a river, stream, &c.
„ *c.* Draining field-works.
„ *d.* Do. the ditches and quarries of permanent works whilst in execution.
„ *e.* Do. fortifications, as complete.
„ *f.* Do. unhealthy positions.

B. *a.* Draining unhealthy districts.

„ *b.* Sewerage.

C. *a.* Territorial. Reclaiming marshes, fens, bogs, &c., for enlargement of territory on all scales—from that executed in Holland, for hundreds of square miles—or in our own colonies of Berbice and Demerara—down to the space to be recovered for large Government establishments, or for fortifications; or that of the private estate, or mere plot, to be rendered available for building ground.

„ *b.* Agricultural. Drying up the above descriptions of ground to afford the soil the advantages of warmth; of opportunities of exposure to contact with fertilizing matters (gaseous, fluid, and solid); and of killing the rank aquatic plants which are too powerful for co-existence with, or are otherwise obnoxious to, those which it is desirable to cultivate.

B and C are very generally connected with such embankments as will keep out the sea; and these embankments have, usually, such sluices as admit or exclude the external waters at pleasure.

The covering in of drains, or leaving them open, is a question, at times, of necessity (as generally in B); at others, of economy,—the decision resting on the balance of profit and loss between the value of the unoccupied surface and the expenses of covering; and in other cases of mere convenience—as in the more expeditious cases of military draining, A*a.* A*b.*, where nothing else could be gained by such an operation.

All that concerns this part of the work will be A*a.* A*b.* A*c.* A*f.*, the remainder belonging to the Second Volume, except as relative to 'Sanatory Precautions,' which see.

A*a.* A*b.*—These are most likely to occur in facilitating siege operations, either by depriving the enemy of the means of flooding the approaches, or to lay open an otherwise inaccessible front. From the probable nature of the case, the measures to be adopted will most likely be of the simplest description, though in determining the volume and course of the stream, care should be taken, if possible, to reserve some control as to continuance; and to calculate effects not only as to the purpose in hand, but on communications in general, by such a body of water entering a new channel. If possible, also, the excavating parties should commence at the end farthest from the point where the waters are to be let out.

The 'measure' above mentioned is the determining a new channel approaching, on the whole, to the straight line A B (figs. 1, 2), by which the contents of the lake, &c., A (which has hitherto received all the waters on the right of the watershed C C), are to cross that line C C, and join the new course B, which may be a gully, or streamlet, leading to quite a different part of the country.

Now it by no means follows that the straight line A B will be the best, though, geometrically, the shortest. Greater facility in excavation, less amount of cutting, greater suitability of ground for the channel, &c., &c., may warrant even such a deviation as A D B; which line need not be constantly in the same plane with A B (as A G H I J B, fig. 3); nor always on a winding course inclined to the horizon at one unvaried angle (as A N′ M′ L′ B, fig. 4),—but so regulated, if possible, that where the ground is not homogeneous as to the consistence of its material, the steepest parts shall be where the rock or soil is hardest, and thus meet the most violent action with the greatest resistance. Nevertheless, the best course will generally be between such limits as are given by A B, A′ B, of figures 3, 4, respectively; as, though much latitude may be allowed the line A D B, fig. 2 in plan, very little can be admitted in section. —*Vide* 'Levelling.'

Fig. 1. Section of Fig. 2.

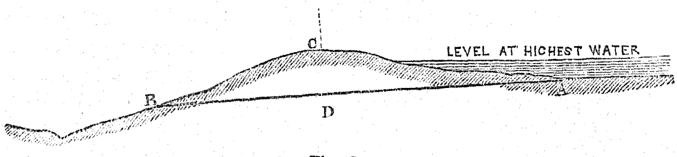


Fig. 2.

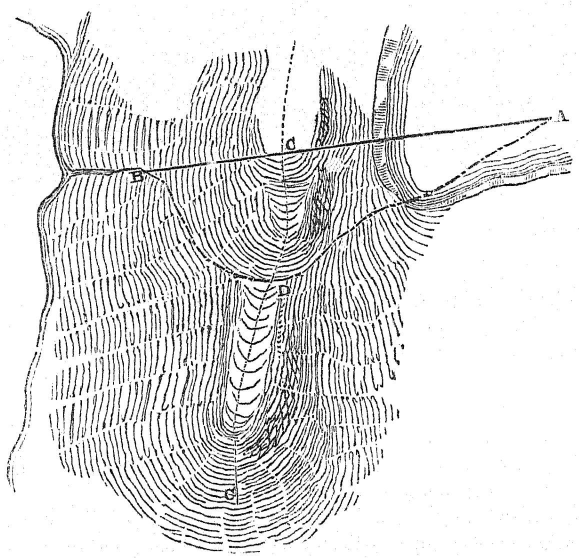


Fig. 3.*
Shewing a line A H I J B in the plane W X Y Z; which line varies in inclination at every point, between 0° and A B O, the angle which the plane W X Y Z makes with the horizon; being 0° at *a* H *a*, *b* J *b*; and = A B O at I, G.

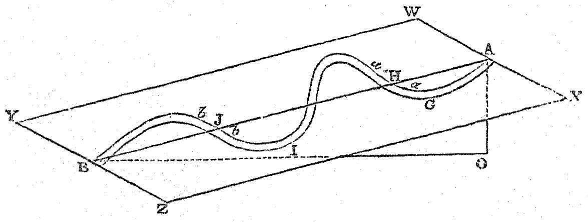
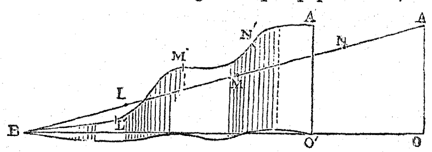


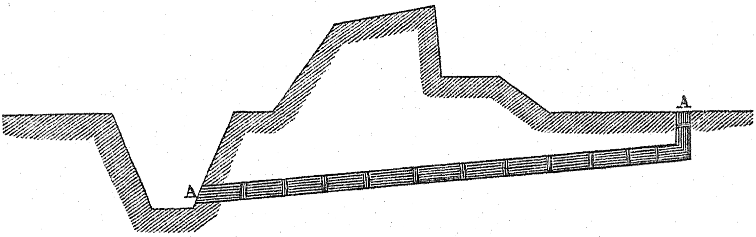
Fig. 4.*
Shewing a line A′ N′ M′ L′ B at one uniform angle (= A B O) with the horizon, as if given by the edge A N M L B of the triangular slip of paper A B O, folded as A′ B O′.



* These diagrams are also of great importance in laying out roads.—*Vide* 'Road Making.' In this last they may be applied to several adjacent and consecutive planes dipping in various directions; but in determining water lines, all these planes can only dip in one *general* direction so as to continue the course downwards.

A *c*.—This can never be very extensive. In small works, where the object is to keep the interior dry, the drains may consist of large fascines, A A (made of branches that would be considered rather too thick for ordinary purposes), let into the ground. Should this be insufficient in larger works, trenches should be cut, and filled in with middling sized gravel, or small rubble;—this is called 'Rubble Draining.' In both cases, leading from the lowest point of the space to be drained, they can pass through the rampart into the ditch.

Fig. 5.



The same can be applied to draining ditches, but then the latter mode is most likely to be in requisition.

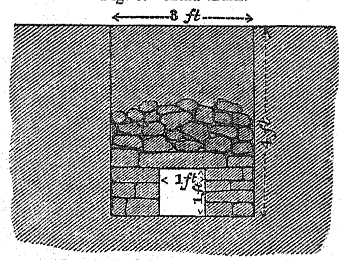
A *f*.—This is mentioned as only applicable on a small scale in the field: where unhealthiness springs from the dampness of the ground, it is more likely to be increased than reduced, in the first instance, by disturbing the soil; especially if there is much decomposed vegetable matter to be displaced. The excessive sickliness at Corfu and Ceylon amongst the troops whilst new roads were being cut under this circumstance is decisive as to 'fact,' whatever may be the theories as to the cause, or even existence, of malaria.

If an extensive position, likely to be held for some years, is to be drained, the troops not immediately wanted should be removed, as much as may be, during the execution of the work; the season should also be considered, and the inhabitants of the country should be employed as much as possible. No detailed course can be prescribed as to the arrangement of the drains, but it is probable that the following sketch of what is done in some of the Irish bogs may be applicable in a general way.

MEMORANDA* OF THE METHOD OF DRAINING LAND IN PART OF THE COUNTY TIPPERARY.

"A general course for the water having first been found,† the levels of the ground are then taken, in order to find the best position for the main drains, for which excavations averaging 4 feet in depth and 3 feet in width are made: these excavations are then built in with dry masonry so as to leave a water-course 1 foot high and wide, covered over with rough flagging or other stone; they are then filled in further with loose stones, and covered with earth: these drains are sometimes 6 feet below the sur-

Fig. 6.—Main drain.



4 ft. to an inch.

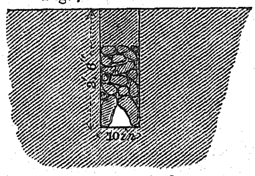
* By Capt. J. Freeth, R. E.

† Where it is not intended to change the water-shed, this "general course" will be often already decided by the old natural water-courses, which may be, in most instances, much improved by clearing and deepening in places, so as to *approximate* to the line A B, in figs. 1, 2. But if it be desired to alter the water-shed,—as for instance from a lake on one side to a river on the other,—then a new channel must be provided, as shewn in the paragraph to which figs. 1, 2 refer.—R. J. N.

face of the ground, and, where there is much water, the dimensions are increased to 1′ 6″ × 1′ 4″.

"For the smaller drains, excavations are made 2 feet 6 inches to 3 feet deep, and 10 inches to 1 foot wide; at the bottom of them stones are placed with the edges leaning against each other, so as to form an arched way for the water to run through, and they are filled in, to within about 1 foot from the surface, with loose stones, broken to about 3 inches cube.

Fig. 7.—Smaller drain.



4 ft. to an inch.

"These drains are placed in ordinary ground about 18 feet apart, but in very wet ground not more than 15 feet, sufficient fall being given to prevent the water from lodging in them: they are led into the main drains as shewn below.

Fig. 8.—Section through *a b*, fig. 9.

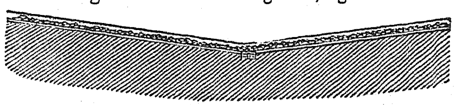
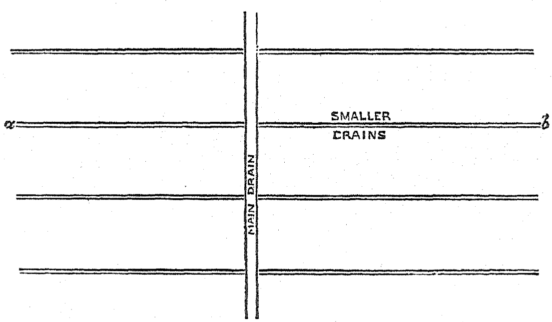


Fig. 9.



Scale 50 feet to an inch.

"The expense and mode of operation will of course vary according to the description of country, the system shewn above being adopted in ground where there is a supply of stone raised in the excavations, which is nearly sufficient for filling in the drains."

R. J. N.

E.

ELECTRICITY—as in various degrees called into existence on any change in the mechanical or chemical constitution of bodies: and the object of all electric apparatus (other than those for scientific investigation) is to *obtain control* over its direction when developed by natural causes, or over its action when produced artificially.

As far as military purposes are at present concerned, we have four principal subjects of application for what practical knowledge is available on this head.

1. The Lightning Conductor.
2. The Electrotype.
3. The Explosion of Mines.
4. The Electric Telegraph, as associated with railroads considered as military communications.

In No. 1, the object is to permit a free neutralization of the electric forces, and thus, as it were, to afford a ready outlet to a violent agency that may do mischief to an indefinite amount, if not provided with such means of escape,—in short, "to make a bridge of gold for a flying enemy," though it will be shewn shortly that gold is no longer considered the best material for that purpose.

In Nos. 2, 3, 4, the intention is to apply to the work intended for it this same power when created and accumulated to any desired extent by apparatus for effecting the changes before mentioned in either the mechanical or chemical constitution of certain bodies.

LIGHTNING CONDUCTORS.

The following notices are intended to embody such principles as are involved in arrangements for lightning conductors. The practical parts have been abridged from Harris's different works, especially that on Thunder-storms; though, respecting any difference there may be between the more theoretical portions of the subjoined and his, it is to be observed, that in arguing on the general development of electricity, that distinguished author's reasoning is built on the Leyden hypothesis of opposed surfaces.

The distinction between 'Conductors' and 'Non-Conductors' is arbitrary; and the line of conduction in all bodies may be considered to lie along the polarized moleculæ composing that line,—whether we refer to metals as so-called 'Conductors,' or to the air as an assumed 'Non-Conductor:' in both the electric action passes from atom to atom along the course taken, though with far greater rapidity in the one case than in the other. In this view of the atmospheric particles forming lines and (thence as connected laterally in mass) *spaces* of conduction, it is considered that electricity is being perpetually evolved from the earth (as from a huge electric machine) by the incessant changes in the mechanical as well as chemical condition of its constituents; such changes, for instance, as those accompanying variations of temperature produced by the enormous extent of evaporation * from the land and fresh water, as well as from the ocean,†—by the absorption and re-irradiation of solar heat; by the escape of central heat; or by the decomposition and recomposition perpetually in progress over the face of the earth, of all descriptions, from slow putrescence to rapid combustion, &c., &c.,—all of which are, more or less, associated with changes in electric condition.

This excited electric condition of the gaseous or other volatile bodies thus released in their course upwards through and mixed with the atmosphere, cannot but disturb the electric equilibrium of its particles inductively; and this action continues till the process reaches the nebulous matters consisting of these vapours, &c., condensed into clouds

* It is right to observe, that this direct evolution of electric action by evaporation is in some degree a contested point.

† The evaporation of sea water produces a greater degree of electrical excitement than that of fresh water.—Kane's 'Elements of Chemistry,' p. 203.

by a change of temperature which determines the existence of electric 'matter' in a form of palpable activity: and when these charged masses approach each other, either by electric attraction, or by the motion of air currents or other causes—then the restitution of the integral and original state of the electricity question takes place; the action of which, when of a destructive character, appears and terminates violently, along and at the end of the chain of intermediate polarized atoms of air, &c., in the forms of sheet lightning, forked lightning, or as the fire-ball or 'thunderbolt.' When of a harmless description, it will be as the 'glow discharge'* (*to* a point)—as the 'brush discharge' (*from* a point), or as the 'summer lightning,' which confines its activity within the precincts of the cloud:—these two groups comprising all the known varieties of lightning.

Although the greater conducting power of metals is thus considered as only a more intense and rapid form of induction,—and relative as the expressions 'conductor' and 'non-conductor' are,—yet the difference of those powers in certain bodies is enormous; that of iron, for instance, being estimated at 400,000,000 times greater than that of water.

The following Table gives in an approximate way the order of precedence in conductive power.

TABLE I.†

	Conductors.		Non-Conductors or Insulators.
Most perfect.	All known metals.	Less perfect.	Ice at 0° of Fahrenheit.
	Well-burned charcoal.		Dried vegetable substances.
	Plumbago.		Dried animal substances, generally.
	Burning gaseous matter, as flame.		Parchment, leather, feathers.
	Smoke.		Baked wood.
	Concentrated acids.		Oils and fatty substances.
Less perfect.	Dilute acids.		Silk.
	Saline fluids.	Most perfect.	Fur and hair.
	Living animals.		Dry gases, including air.
	Living vegetables.		Pure steam of high elasticity.
	Wood, in its ordinary state.		Glass and all vitrefactions.
	Snow, and ice from 32° to 0°.		Diamond and transparent gems.
	Water.		Talc.
Imperfect.	Aqueous vapour.		Amber.
	Common earth and stone.		All resins and resinous bodies.
	Dry chalk and lime.		Brimstone.
	Marble and porcelain.		Shell-lac.
	Paper.		
	Alkaline matter.		

The ratios of heat evolved, and of those of conducting power, are shewn as follows.

TABLE II.‡

	Heat evolved.	Conducting power.
Silver	6	120
Copper	6	120
Gold	9	80
Zinc	18	40
Platinum	30	24
Iron	30	24
Tin	36	20
Lead	72	12

* 'Comazants'—'St. Elmo's fires,' &c.
† From Harris on Thunder-storms.
‡ As given in Kane's 'Elements of Chemistry.'

Hence it is unnecessary to use gold or silver, as has been suggested in former times; the power of copper being equal to that of the latter, and superior to that of the former.

As concerns the extent of electric action always in existence, Faraday asserts that there is electricity enough evolved in the decomposition of a single drop of water to form a flash of lightning: and with reference to the rapidity with which it passes, Wheatstone (with an apparatus that enabled him to measure time to the $\frac{1}{152000}$th of a second) determines the progress of accumulated electricity as at times 576,000 miles per second, that of light being 195,000 miles.*

The electric 'fluid' will invariably *select* for itself the line of shortest conduction offered by the best conductors at all near its course in a building, ship, &c.: the following diagrams from an original experiment by Harris illustrate this principle fully.

Fig. A.

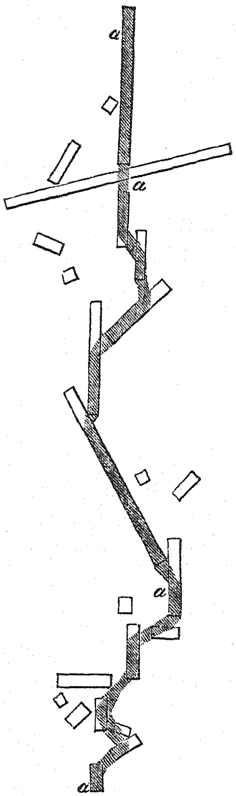
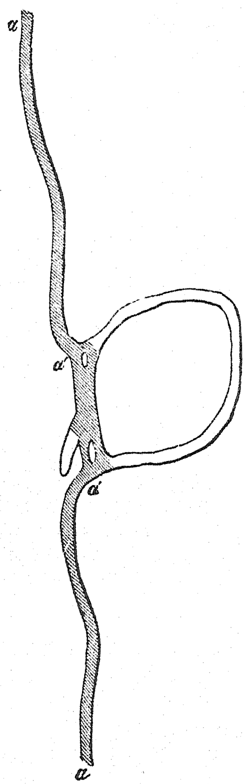


Fig. B.



Figs. A, B.

The shaded part shews the direct track (*a a*) taken by the electric fluid along a line of metallic conduction, disregarding every thing but its own course. Fig. A may represent the conducting masses in a building. Fig. B, the passage of the fluid across the bight of a wire-rope, or of a chain.

Hence the principal danger in using chain or wire conductors in the upper masts of shipping, as when these last are lowered they are apt to leave the chain or wire-rope hanging loosely; and when handling this as a bight, the seaman's body becomes the shortest course (*a′a′*, fig. B) for the electric action, on the very same principle that a metallic rod-conductor of proper dimensions may be passed through a barrel of gunpowder with perfect safety, though a chain would ignite it at once.

* "According to Struve's latest researches, 166,072 miles."—Kosmos, p. 163.

The expressions of the most important electric laws concerning the subjects of this Paper, as determined *experimentally*,* are as follows; where

C represents conducting power.
D „ distance between two opposed surfaces.
F „ attractive force between two surfaces so opposed.
H „ heating powers, referring to solidity and transverse section.
L „ length of conduction.
Q „ quantity of electricity in the charge.
S „ surface over which Q is spread.

The Attractive Force between two *opposed* surfaces varies—

If between a charged and a neutral free conductor, { directly, as the square of the quantity of electricity, inversely, as the square of the distance, „ as the square of the surface, } $F \propto Q^2$ or $F \propto \frac{1}{D^2} \propto \frac{1}{S^2}$

If between an unchangeable positive and negative surface, { directly, as the square of the quantity of electricity, inversely, as the distance, } or $F \propto Q^2 \propto \frac{1}{D}$

The Conducting Powers of different rods of the same metal vary therefore—

in a higher ratio (apparently) than as the surfaces, though they are not asserted to do so as the squares, } or $C \propto S^2$?†

They vary inversely as the length; and directly as the square of the diameter of the solid rod, } or $C \propto \frac{1}{L} \propto d^2$

The Heating Effect (referring to solidity) varies—

directly, as the square of the quantity of electricity, inversely, as the area of the transverse section, „ as the length of conduction, } or $H \propto Q^2 \propto \frac{1}{\text{area of section}} \left(\text{or } \frac{1}{\text{diameter}^2}\right) \propto \frac{1}{L}$

APPLICATION OF THE PRECEDING, AND OF SUCH INFORMATION AS EXPERIENCE HAS HITHERTO SUPPLIED.

References.

Table II. Copper is the best conductor: the rods should not be less than ½ inch diameter, if solid; ¾ inch is preferable, and generally ample. If hollow, may be from 1 to 2

Figs. 1, 2, 3. inches in diameter, and about $\frac{1}{5}$ inch thick.—*Vide* figs. 1, 2, 3, Plate I.

If iron rods be used, they should not be less than ¾ inch diameter when solid: if hollow, not less than 2 inches diameter and $\frac{3}{10}$ inch thick, and jointed as in figs.

Figs. 1, 2, 3. 1, 2, 3, Plate I.—By B. O., 24th July, 1829, $\frac{E}{510}$. "Solid iron rods 1½″ diameter,—top of copper,—tipped with gold."

$C \propto S^2$? $H \propto Q^2 \propto \frac{1}{d^2}$ $C \propto \frac{1}{L}$ } The Hollow Conductor (if sufficiently thick for stability) is better than the solid rod of equal length and weight, because the metal should display as much surface (in lateral dimensions) as possible consistently with strength,‡ to reduce the intensity of action on surface, and heating effect in transverse sectional area; but unnecessary length should be avoided.

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* The writer of these notices has been gratified, through the kindness of his friend Mr. W. Snow Harris, with a sight of the experiments on which the most important of the above formulæ were deduced: it is difficult to conceive any such demonstrations more interesting, or more rigid, than were afforded by this accomplished experimentalist.

† All the formulæ except this are taken from Harris on Thunder-storms, or from his Paper on the Laws of Electricity, Phil. Trans. 1839.

‡ In remote colonies, sufficiently good workmanship cannot always be commanded for the tubular conductor: the solid one requires no skill beyond that of a common blacksmith.

Figs. 5-9. The conductor should involve in its course the principal detached masses of metal in or on the actual walls and framing of the building or ship: if not allowed this course freely, it will be apt to take it in a summary and violent manner.

It should be placed as close as possible to the walls, &c., which are to be defended,—not at a distance from them; and should be carried down at once directly into the ground; and when below the surface, it should then divide into two or more pointed branches (*a a a*, fig. 4) slanting away from the building. If circumstances permit, the lower end should pass into a well, or a stream, or a drain,* or at all events into earth that can generally be kept moist from any neighbouring gutter. It is a useless precaution to pass conductors through glass linings and holdfasts, as has been recommended, since the lightning will always take the direct course down the rod until interrupted; on which last account—

Fig. 4.

Diagram B. Chain conductors are very inferior to those of rod, being a series of interrupted conductions from which the lightning is ready to turn aside at any point of contact of the links,—provided that at such point a freer and easier line of conduction be offered by some neighbouring body than what the chain itself affords.

$$\left.\begin{array}{l} C \propto S^2? \\ C \propto \frac{1}{L} \\ H \propto Q^2 \propto \frac{1}{d^2} \end{array}\right\}$$

The conductor should be attached to the most prominent points of the building (fig. 5): if its length be very considerable, its tranverse dimensions must be increased; and in doing this, the provision for a sufficient conducting surface insures that for the heating effect.

In ornamental buildings, such as honorary columns, &c., for the sake of appearance, the conductor may pass down withinside; it must, however, be firmly fixed, and the line of conduction made and kept complete and undisturbed.

In extensive ranges of buildings, all the most prominent points should have long-pointed rods projecting freely into the air, at least 4 or 5 feet above the building; and the larger the range the higher they should be. Fig. 5.

Fig. 5.

It does not appear that any single conductor hitherto made can insure beyond a horizontal radius of 40 feet: hence, in practice, less should be taken; though a wider range may be allowed if the roofs be of zinc, lead, copper, or any other metal in *well-connected* sheets; or if the ridges and hips only be thus guarded, and the whole well joined to the conductor, and to iron gutters and pipes, now commonly used, and a free passage be provided to the ground at different places. The points of contact must be numerous to reduce the heating effect (or chance of fire) at such points, as the whole electric action will condense there, having still to pass through them on its way down. There is no reason why lightning conductors should not be painted or lacquered.

In addition to the diagrams given in figs. 1–3 (Plate I.), shewing the construction of hollow conductors for buildings,—those for the protection of shipping, figs. 6–9, are likewise noticed, as probably providing for the most complicated cases that are likely to occur in the most extreme cases on land,—as in the case of flag-staffs with tops, &c., &c.

Plate I.

Fig. 1. The mode of joining two lengths of copper tube (*a*, *b*) by means of a double screw (*c*) with a shouldered collar (*d*).

Fig. 2. The staple (*a*), by which the conductor is supported at the joints and fixed to the wall.

* By B. O., 18th March, 1846, $\frac{E}{406}$. "Covered cisterns are to be preferred to open trenches, as being less liable to evaporation;—that there be a man-hole; and that all Storekeepers, Barrack-Masters, or others in charge of buildings with conductors, do by weekly or daily inspection ascertain that the cisterns are kept full; for which they will be held responsible."

Fig. 3. The head of the conductor.

Fig. 4. Conductor complete, shewing the lower termination (*a, a, a*), as buried in the ground, or received in water.

Fig. 5. Application of conductors;—the points *a, b, c, d, e,* &c., connected by bands of metal (*c n, d t, e h,* &c.,) into one general whole.

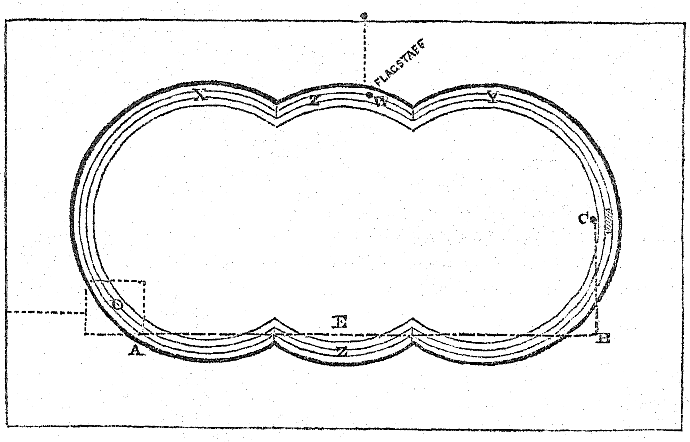
Fig. 6. Ships' conductors, consisting of two stripes of sheet copper, from 1·5 to 5 inches wide, and from $\frac{1}{8}$ to $\frac{1}{16}$ inch thick, in lengths of 4 feet. They are let double into a groove in the mast, so as to insure continuity of conduction by breaking joint, as shewn in the figure: these stripes are kept in thorough contact, and are secured to the mast by copper nails, 6 inches apart, in the drilled and countersunk holes (*a, a*). The upper surface of the upper piece (A, A) is slightly rounded so as to conform to the surface of the mast in transverse section.

Fig. 7. "The cap (*a b*) and the hole (*b*) through which the moveable mast (*e x*) slides, are furnished with similar plates; these are led from the square hole at *a*, by which the cap (*a b*) is fixed to the head of the mast (D), into the round hole at *b*; and there is a lining of copper in this part of the hole next to the conductor at *b*, by which the metallic line is continued to the next mast (D)."

Figs. 8, 9. "The bolts, (*a, b, c, d, e, f,*) passing through the ship, and in which the general line of conduction terminates, are clenched upon metallic rings and plates, in connection with the copper sheathing; and there are additional bands (*m n,* fig. 8) leading from the fore-mast and mizen-mast directly to the stem or stern under the decks; other bands (*g h,* fig. 9) traverse the beams, and they all terminate in the sea by bolts clenched on the copper sheathing."—"Fig. 9 is a section suited to the beams abaft each mast."

Memorandum of damage done to one of the Towers on the Coast of Ireland, 13th March, 1844.

The truck of the flag-staff was destroyed,—the rest left uninjured; the ashlar masonry at the foot of it (W) a good deal shaken.



From W the electric matter forked right and left, disturbing the iron racer (4 inches broad × $1\frac{1}{2}$ thick) at X, and at C breaking out a fragment weighing about 4 lbs., which it hurled over the parapet (4 feet high) to a distance of about 50 yards in front. All this was done to find a passage for itself through the stone banquette (18 inches high) on which the racer lies, to the mouth of the lead water-pipe at the foot of this banquette, just under C,—and destroying the intermediate masonry in so doing.

From C the discharge followed the large leaden pipe (C B A, 3 inches diameter) to A, where it projected over the tank (D), but without touching it;—thus isolated, at A the pipe was burst: no further trace of electric action could be discovered,—though, from the condition to which the pipe was reduced, it was a happy circumstance that the lightning avoided the magazine at E, towards which there was no very obvious reason why it did not turn.

N. B. Proper conductors have been since fixed, and in connection with the principal metallic masses. R. J. N.

ELECTROTYPE.*

An application of voltaic electricity to the art of copying, is a branch of the larger subject which embraces the art of working in metals by voltaic electricity, aptly termed Electro-Metallurgy by Mr. Smee, to whose researches, and those of Professor Grove, the subject is greatly indebted for the rank it holds.

Electrotype—copies by precipitating metals from solution, either upon the object to be copied, forming a coating over it, which when removed is of course a matrix or mould;—into which metal is again thrown from solution, and becomes a duplicate or copy of the original;—or by precipitating the metal into a mould formed by any other means.

Metallic substances are most easily copied, because from their conducting powers they become part of the voltaic circuit; but other subjects, as busts, vases, or casts of any kind, or fossils, or objects of natural history, may readily be made recipients of the deposit, by coating them with some conducting substance.

APPARATUS.

It would be impracticable within the limits of this Paper to detail the various kinds of batteries, or arrangements, or forms of plates; they are described in numerous works of easy access,† and have been varied at the discretion, almost the fancy, of the operator. It is sufficient to say that the battery known as Daniell's has the greatest *constancy* of action, and that Grove's affords the greatest *intensity:* but *quantity*, which is the element most required in the operations of electro-metallurgy, is most advantageously procured when working on the large scale, from the construction proposed by Mr. Smee, because quantity bears a direct relation to the extent of

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* By Captain Larcom, R. E.

† Among which may be especially mentioned Kane's 'Elements of Chemistry,' Daniell's 'Chemical Philosophy,' Smee's 'Electro-Metallurgy,' and a very modest little work, Walker on 'Electrotype Manipulation,' together with occasional Papers in Scientific periodicals.

surface in the plates; and Mr. Smee's dispenses with the interior porous vessel, which cannot conveniently be procured or used of a large size. This battery is besides remarkable for its simplicity of construction and application; and though it has not the constancy of Daniell's, or the energy of Grove's, it may be kept in active operation for a considerable time, when supplied with a sufficiency of acid. For, although quantity is the most important property in electro-metallurgy, all are concerned in the successful practice of it: and all the batteries may be greatly modified in their effects, by the nature, strength, and temperature of the solution from which the deposit is to take place, as well as of that which excites the battery; the size of the plates, the size, and even the form, of the object to be copied, as well as the length of wire through which the circuit is to be made. By different combinations of these elements, valuable results may be obtained from any of them; Mr. Smee states, in fact, that with any sized negative plate, with any amount of salt in solution, with any sized battery, and at any temperature, we can obtain the reduction of any metal, in any state we please. The operator, therefore, must not expect to find any one process suitable to every application of electrotype, but making himself master of the principles which are common to all, must apply to the best advantage the means which circumstances place at his disposal.

The first example of electro-metallic deposit, though accidental, points indeed to the general circumstances necessary for its production. Professor Daniell, in the course of his ordinary experiments, observed that the copper deposited on the outer vessel of his battery, from the dissolved sulphate which filled it, contained, when removed, an exact impression of various minute scratches which happened to be upon the vessel. This outer vessel was itself of copper, and if now, instead of copper, we make the vessel of glass, or porcelain, or protected wood, immerse a piece of copper into the solution of sulphate, and connect it by a wire with the zinc within the porous tube, the deposit, which formerly took place on the vessel, will take place on the piece of copper, and produce a mould, which being removed, and itself connected with the wire, will in its turn receive the deposit, that deposit becoming a copy of the original; the strength of the solution being maintained by adding fresh crystals of the sulphate in the usual way. (See fig. 1, Plate I.) What is here described of copper may be applied to the deposit of any other metal, either upon metal, or upon any other substance properly coated, by a due arrangement of the solution, and of the plates: but it is proposed here to pursue the subject chiefly as to copper, as most generally useful.

It may here also be said, that the moulds may of course be made of any other substance, if more convenient, as plaster, or any soft metal, by pressure or fusion. In the latter case, the metal must be one which will not be acted on by the solution into which it is to be plunged. In the case of plaster, it must be saturated with oil, or coated with varnish, and all such non-conducting substances must be rendered conductors by a coating, such as black lead, which may be laid carefully on by a camel-hair brush, and presents a smooth polished surface. A beautiful coating may also be given to some minute subjects by reducing metal from a solution chemically. This is peculiarly applicable to delicate membranes, or objects which will not bear even the brush. A very elegant mode of accomplishing this has been introduced and patented by Mr. Parkes, of Birmingham, thus described by himself:

"A solution of phosphorus is prepared by adding to each pound of that substance 15 lbs. of the bisulphuret or other sulphuret of carbon, and then thoroughly agitating the mixture. This solution is applicable to various uses, and amongst others, to obtaining deposits of metal upon non-metallic substances, either by combining it with the substances on which it is to be deposited, as in the case of wax, or by coating

the surface thereof. Any of the known preparations of wax may be treated in this way; but the one preferred is composed of from 6 to 8 oz. of the solution, 5 lbs. of wax, and 5 lbs. of deers' suet, melted together at a low heat, on account of the inflammable nature of the phosphorus. The article formed by this composition is acted upon by a solution of silver or gold, in the manner hereafter described, with respect to articles which have been coated with the solution.

"If the solution is to be applied to the surface of the article, an addition is made to it of 1 lb. of wax or tallow, 1 pint of spirits of turpentine, and 2 oz. of India-rubber, dissolved with 1 lb. of asphalte in bisulphuret of carbon, for every pound of phosphorus contained in the solution: the wax or tallow being first melted, the solution of India-rubber and asphalte is stirred in; then the turpentine, and after that the solution of phosphorus, are added. The solution prepared in this manner is applied to the surfaces of non-metallic substances, such as wood, flowers, &c., by immersion or brushing; the article is then immersed in a dilute solution of nitrate of silver or chloride of gold: in a few minutes the surface is covered with a fine film of metal, sufficient to insure a deposit of any required thickness, on the article being connected with any of the electrical apparatus at present employed for coating articles with metal. The solution intended to be used is prepared by dissolving 4 oz. of silver in nitric acid, and afterwards diluting the same with 12 gallons of water; the gold solution is formed by dissolving 1 oz. of gold in nitro-muriatic acid, and then diluting it with 10 gallons of water."

It is remarkable that by this process the deposit over every part of the surface is instantaneous, in this respect differing materially from the deposit on the ordinary coating of black lead, which is gradual, beginning at one or more points, and growing, as it were, over the whole surface.

It must also be remarked, that the deposited metal commonly peels off the objects or mould with great facility, from the film of air which always adheres to it; but as it is sometimes desirable to make the deposited metal adhere, that effect may for most practical purposes be produced by washing the plate with a solution of caustic potash, or with nitric acid, or by heating the plate and plunging it in that state into the solution or into water. This, however, is not always successful, nor, indeed, is it by any means clear that the presence or absence of air is the cause or the preventive of adhesion. In the case of metals, a perfect mechanical polish would seem to be sufficient to prevent adhesion, just as water thrown on a highly burnished plate runs off again without wetting it; and roughness, when produced chemically, so as to expose the crystalline structure of the metal, will no doubt cause the deposit to adhere, but the immersion must very rapidly follow the chemical roughening, or the surface will become oxydized. A very simple mode of roughening is by merely reversing the poles of the battery for a few minutes. The power of separation, however, is all-important, and it has not been deemed sufficient on the large plates of the Ordnance Survey to trust to their polish alone. The mode adopted is to clean out the plate thoroughly with oil, and clean off all the oil which can be removed by rubbing; then brush the plate carefully with bread, which, when removed as far as possible, appears still to leave some film behind it, for the plate is then heated and a small quantity of wax applied, which, instead of spreading with difficulty, flashes readily over the plate. This wax is then removed as far as possible, the plate continuing heated; but some minute quantity would appear still to remain, probably filling the inevitable flaws and roughnesses which exist on the best copper. Care must be taken not to touch the plate after it is cooled, or partial adhesion takes place on the parts touched. There is no portion of the whole process of electrotype which requires more care than this. For want of attention to it, or the application

of improper means, many persons in endeavouring to multiply copies have entombed their work for ever. The adhesion when under command, however, is very useful for backing plates or casts, &c.; and lest the deposited metal grow round the back or edges of the plate, it is necessary to coat those parts with varnish or grease, which prevents the deposit taking place.

The form of Daniell's battery may be modified when it is more convenient to place the object in a horizontal position by throwing a porous diaphragm horizontally across a flat box instead of using the vertical porous tube, or in various other ways which will occur to every operator in the course of his work. The principle, however, common to all this class of apparatus, which has been called *the single cell*, is, that the metal is precipitated at the negative pole of a simple battery. But it will be found that in whatever way a metallic substance can be rendered negative, so that hydrogen shall be evolved at it, there will the metal be precipitated.*

We may therefore use any battery which is sufficient to decompose acidulated water between platinum poles, and it will be found that metal will be deposited at the negative. Here is presented an immense advantage. We can separate the battery from the decomposing *trough*, and instead of replenishing the solution by adding crystals, or by other mechanical means, we can use the affinity of metals for oxygen to effect their decomposition; and for the positive platinum pole, substitute a plate of the metal we wish to precipitate, *i.e.* the same as in solution. Then, as the metal is deposited from the solution, the oxygen and acid being set free, will dissolve the positive plate, and maintain the solution of the same strength. (See fig. 2, Plate I.)

The form of the precipitating trough must depend on the size and form of the object to be copied; the solution,—on the metal to be thrown down. The battery may vary also, always remembering that quantity is more concerned in electrotype operations than intensity. The intensity we can vary by increasing the series, by using different exciting liquids in the battery, or diminishing the distance between the plates in the trough; the quantity, by changing the relative size of the plates in the battery, by joining the zincs of several pairs, or by increasing the strength of the battery liquid. When the operations are to be of long duration, it is important to adopt the arrangement which will give the most economical amount of power. This may also be obtained in most cases from a single pair, always having relation to the surface intended to receive the deposit, besides which, a certain degree of density or 'tension' of electricity exterior to the battery would appear necessary; but it may be interfered with by the resistance of the solution, because solutions, like metals, are subject to variety in their conducting powers, and the passage of the current may be resisted by various causes; among others, by the distance through which it has to pass, the nature, the strength, and the temperature of the solution; by altering the one or the other of which, the resistance may therefore be diminished. It is also to be remarked in reference to the solution, that the presence of metallic particles in the solution, such as sulphate of iron added to a weak solution of sulphate of copper, for example, will facilitate the deposit of copper.

LAWS.

It is desirable to explain succinctly the laws which regulate the deposit of metals

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* It may here be remarked, that for convenience, throughout this Paper the composition of the salts is spoken of as formerly understood, not according to the newer theory, by which sulphate of copper, for example, consists of sulphuric acid + oxygen + copper instead of sulphuric acid + oxide of copper—the practical results being, for the present purpose, the same.

from their solution, a due knowledge and recollection of which will guide the operator in the use of them, as a knowledge of the principles on which batteries and other apparatus depend will guide him in using the one or the other. Mr. Smee has reduced them to three.

1st. The metals are thrown down *as a black powder* when the current of electricity is sufficiently strong, in reference to the strength of the solution, to cause hydrogen to be violently evolved from the negative plate of the decomposing cell.

2nd. They are thrown down *in a crystalline* state when there is no evolution of hydrogen, and no tendency to it.

3rd. They are thrown down in a *reguline* state (*i. e.* having the properties of ductility and malleability) when hydrogen is on the point of being evolved, when the minutest quantity of gas begins to appear at the negative plate.

Here then we require the combined influences of quantity and intensity, and are guided to the best arrangements. We require sufficient strength in the battery to act upon and dissolve the replenishing plate. Now if we pass a large quantity of electricity through a weak solution, we shall have the metal deposited in the utmost state of brittleness. The reverse will produce large crystals of the utmost hardness. The principal powers of change we possess, are, the size of the battery, the strength of the solution, the arrangement of poles in the decomposing cell, and the temperature of the solution.

We can obtain the black powder

1st. *From any given solution*, by increasing the intensity and quantity of the battery, by a series, by altering the size of the negative poles, and by increasing the temperature.

2nd. *With any size of the negative plate*, by increasing the intensity and quantity of the battery, by increasing the positive electrode, by weakening the solution, adding to its acid, and approximating the poles.

3rd. *With any given battery* sufficient to decompose water, by diminishing the size of the negative pole and increasing the positive, by approximating the poles, or weakening the solution with dilute acid.

We can obtain the metal in a crystalline state

1st. *With any given solution*, by increasing the quantity and diminishing the intensity of the electricity, by increasing the positive and diminishing the negative pole, and approximating them.

2nd. *With any given negative plate*, by diminishing the intensity of the battery, enlarging its size, saturating the solution with the salt, enlarging the positive plate, and approximating it to the negative.

3rd. *With any given battery*, by strengthening the solution, diminishing the negative electrode, increasing the positive, and approximating them.

Our great object, however, in electrotype is to obtain metal in the reguline state, *i. e.* to obtain the exact point of evolution of the hydrogen, and it is by no means easy to lay down any general rule. If it be too abundant, we may increase the negative pole or diminish the positive. But if we wish to have the poles of the same size, which is often indispensable, we may reduce the size of the battery plates, or weaken its exciting acid. Variation in the distances between the poles will also regulate the evolution of hydrogen sufficiently in some instances; or supposing all these impracticable or inconvenient, we may keep the evolution under tolerable control, merely by regulating the strength of the metallic solution, and the quantity of acid it contains. The following experiment exhibited these laws in a very simple way. A slip of copper was immersed in a tall jar having a stratum of highly acidulated sulphate of copper at the bottom (about 2 inches in height), another stratum

of solution saturated with the salt, a third of the same solution diluted with an equal quantity of water, and a fourth diluted with twice its quantity of water. A slip of the same size formed the dissolving plate, at a distance of half an inch. The above, connected with a Smee's battery, in a solution of water 30 : 1. sul. acid, arranged for quantity. At the bottom, the quantity deposited was small and crystalline. Between the saturated and half-saturated solutions it was most abundant and elastic. The next above was spongy, and at the top was a dark brown powder.

With the same battery arranged for intensity, all other circumstances the same, the effects to the eye were very similar, but the deposit was more copious.

The deposit from the semi-saturated solution in both cases was the best, *i.e.* the most reguline, but it became more granular as the intensity increased.

It may be useful to describe the mode of arranging the same battery for quantity and for intensity. In the first case, the zincs are connected with each other, and the plates of platinized silver with each other, as in fig. 3, Plate I. In the other, the zinc of the first pair is connected with the platinized silver of the second, as in fig. 4, Plate I. These modes of increasing quantity and intensity may be extended to the connection of any number of pairs, but if the experiment be of long duration and arranged for intensity, it is peculiarly important that the zinc plates should be all of equal purity, as, if the existing liquid of any cell become saturated by a greater amount of local action on the zinc, its exciting power will cease, and that cell will become in fact a decomposing trough, depositing zinc on the negative plate. This peculiarly recommends the single-pair arrangement for the purpose of electrotype.

APPLICATIONS.

The principal use which the Engineer Department has hitherto made of electrotype is in the duplication of engraved copper-plates on the Irish Survey, to which purpose, after numerous preliminary experiments, it was first practically applied in 1840, for inserting contours in the county of Donegal.

It affords a mode of multiplying maps *ad libitum,* and preserving the original plate, by providing duplicates from which impressions may be taken, while the original plate remains wholly uninjured. It also affords a convenient mode of representing various kinds of information on the same outline or ground-work, as for example, in the illustrative plates of the late Census of Ireland, the same outline map is used to represent on successive plates, the density of population, the extent of education, and other subjects, merely by making as many electrotype copies of the first plate in its outline state as are required, and completing each copy with its peculiar information. A matrix is then taken from each plate, the matrices joined, and the duplicate produced in a single plate, so that, in printing, an impression is taken from the whole number so joined, with each passage of the plate through the press. It also affords great facility for the *correction* of maps, and insertion of new matter, by substituting for the ordinary mode of correction (viz., erasing or scraping out the erroneous work, and hammering up a new surface from the back to receive the correction,) the more exact and less costly mode of merely scraping the erroneous work from a matrix, which yields therefore a blank copper in that place. The smallest spot in the most crowded work, as a house in the midst of a town, for instance, can be corrected by this means, which by the ordinary mode would always require the sacrifice of a greater or less quantity of correct work around it. In this way a plate containing the city of Dublin has been corrected for less than one-fifth the expense of re-engraving.

The battery which has been found most suitable is that of Smee. Its simplicity of construction, requiring but a single cell, was very important in plates of the size

required, where porous cells would have been very expensive, if practicable. The cheapness of the exciting acid (sulphuric), and the greater ease of cleaning the single zinc element, than the numerous zincs where porous cells are used, with the consideration that quantity was the great desideratum, at once recommended it, and after various experiments it has still remained decidedly the best. These experiments resulted in fixing the size of the battery plates, in relation to the surface over which the deposit was to take place, which is 2′ 3″ × 3′ 3″, about 7 square feet, as follows. A pair of silver plates platinized, *i.e.* coated with comminuted platina precipitated from its chloride solution, each 2′ 8″ × 2′, therefore exposing about 10½ square feet of surface, with a zinc plate between them, 2′ 4″ × 1′ 8″, exposing also about 7¾ square feet, *i.e.* equal to the plate which is to receive the deposit, and weighing about 80 lbs., fixed in a frame (Plate I. fig. 5), were plunged in a cell* charged with water and sulphuric acid, in the proportion of 30 to 1,† and connected with the plates in a horizontal decomposing trough, filled with solution, kept in a state approaching to saturation, by a dissolving plate of rolled copper of the same size as that which was to receive the deposit. Means were also provided to agitate the solution. A sketch is given of the apparatus in Plate II. In the sketch, the negative, *i.e.* receiving plate, is downwards, in which position the copper is deposited most rapidly, and the solution kept in the most equal state; but the copper is very porous, and a far better copper is obtained by placing the negative plate, *i. e.* the plate which is to receive the deposit, upwards: in this position the deposit takes place more slowly, the metal is far more compact, will bear hammering, and the erasures always necessary in engraving; technically speaking, in fact, is in a more reguline state. It is, moreover, free from the danger of receiving the particles of dirt and impurity which fall from the dissolving plate. It may sometimes be convenient to give the new plate a face of this good copper, and thicken it by reversing the plates afterwards; or a thin sheet, of the thickness of strong paper merely, may be formed, and folded round a common plate for printing, as paper is folded round a card for sketching on. This has been frequently found convenient on the Survey. In both positions, however, but especially when the negative plate is upwards, it is essentially necessary to agitate the solution, in order to remove the air bubbles which adhere to the plate, and especially to keep the solution of equal strength and density throughout, as the fluid in contact with the plate rapidly loses its copper, slackens in its rate of deposit, alters in quality, and in time would stop altogether. The troughs are provided with an arrangement for this purpose, and to the apparatus is also added an extremely simple and neat contrivance, by which the acid solution in the battery is kept at the same strength. The whole of these arrangements are due to Mr. William Dalgleish, by whom they are managed. The changes even of temperature were to a certain extent met by this self-supplying apparatus, as during the night, when the thermometer fell, a greater quantity of acid was given into the battery, and maintained the action. The copper is found to be sufficiently good when about 1 lb. is deposited in 24 hours. This has been tested by rolling and hammering. As a measure of economy it will be found convenient to make the matrix such as will render it useful for other purposes, because, not being easily soluble from its superior purity, it cannot with advantage again be used as a dissolving plate. On the Survey this will be accomplished by making the

* This and all the other water-tight boxes and troughs, described in the Ordnance apparatus, are double deal boxes—one within the other, with a layer of marine glue between, which has been found better than pitch, from its elasticity—being thus free from the danger of cracking by any accidental blow the box may receive.

† The acid spoken of in this Paper is in all cases the ordinary acid of commerce.

matrix sufficiently thick to be used as a new plate for engraving on, by merely erasing the relieved work, and putting a face upon it in the ordinary way. If reflecting telescopes should become common, this copper will be most valuable for specula, and it is already sought after by the goldsmiths as an alloy from its peculiar purity. For economy also in working on a large scale, it will be useful to find a market for the sulphate of zinc which is formed in the battery cell, so that its sale shall in part repay the expense of other material. It is probable such a market may be found in the cotton manufacture.

It is very necessary to be careful in selecting pure acid. The sulphuric acid manufactured from pyrites commonly contains a considerable quantity of arsenic, the presence of which is fatal by being precipitated on the zinc plate and causing local action. This is the more dangerous from its insidious progress, not being perceived till the galvanic action has been some time in operation. A convenient mode of detecting its presence is to immerse a pair of small plates in a small quantity of acid solution somewhat stronger than that used in the battery; complete the circuit for a few minutes, and then break it, when, if arsenic have been precipitated on the zinc, it will be immediately detected by the local action it causes.

The apparatus figured in Plate II. was erected in 1841, since which it has been found that the constancy of action in the battery may be conveniently maintained, merely by supplying its waste occasionally, provided the quantity of exciting liquid be sufficient; and instead of separate cells of 60 gallons for each battery, as at first used, a cell has been constructed containing 1500 gallons, into which 4 pairs of plates are plunged, each thus having 375 gallons, and the liquid being occasionally maintained by the addition of as much acid as the diminished weight either of the zinc plate in the battery, or the dissolving plate in the trough, shews to have been taken up to form the sulphate, and the working of the apparatus being exhibited on a galvanometer attached to each pair of plates. The large dimensions of this cistern afford the advantage of placing the battery plates in an oblique or horizontal position by a simple arrangement of the mercury, facilitating and maintaining the amalgamation of the zinc, so that, it being no longer necessary to remove the zinc so frequently for that purpose, it may be increased to a considerable weight, and the battery left in its cell for a much longer time.

In this construction also the plates may be made of slips of metal, which, more especially in the negative or silver plate, is of great advantage, from the facility and economy it affords in the operation of platinizing, usually one of much delicacy and difficulty in large plates. In this arrangement the sulphate of zinc which forms in the bottom of the cell is drawn off by a syphon, a false floor being provided to receive the plates. It is not thought necessary to figure this newer apparatus in the present Paper, as the former is sufficiently effective for all cases likely to occur in ordinary service.

A few lines may, however, be added on the great importance of agitating the solution in the decomposing trough, to which, as well as to the position of the plates in the trough, it will always be found necessary to attend very carefully, whatever arrangement may be adopted for the battery plates. A very simple experiment will shew that the change in the character of the precipitated metal, when the dissolving and receiving plates are in different positions, arises from the changing of the density of different parts of the solution when the battery is in active operation.

If a copper dissolving and receiving plate be placed vertically in a glass jar filled with a solution of sulphate of copper, and attached to a small battery in good working order, and the solution narrowly watched, that portion from which the metal has been precipitated will be seen to rise from the upper edge of the receiving plate to the top

of the solution, while a stream of greater density will be seen to flow from the lower edge of the dissolving plate to the bottom of the jar, and in time crystals of the salt become formed at the bottom of the jar, while the solution at the top will become colourless as far down as the upper edge of the dissolving plate; so that if the receiving plate project above the dissolving plate in the solution, it is obvious no metal can be deposited upon it, although the dissolving plate will continue to be acted on. When the plates are in a vertical position, facing and parallel to each other, the deposit becomes unequal, *i. e.* upon the lower portion it is much thicker than upon the upper: it is generally studded with globular concretions of the metal, and lines or grooves extending upwards, while the upper part remains thin; and when the solution comes to a certain stage of saturation, or rather of exhaustion, it is covered with the sandy deposit, and at last a dark brown powder.

The same inconvenience is felt in the horizontal position, and from the same cause. When the receiving plate is under the dissolving plate, the solution in contact with its surface rapidly becomes of different density in different parts; and as some portions of it are thus more favorable for deposition, a current is established, and maintained, if the solution is not disturbed. Under certain circumstances, the metal grows vertically in needle-shaped points, to the height of half an inch or more, nearly completing the circuit by contact with the other plate. Under ordinary circumstances, the back of the plate becomes studded with the minute globes before described, which from their lateral growth meet, but have no cohesion, and are in their turn covered with others. Under other circumstances, the plate becomes covered with circular cavities, which become smaller as the metal is precipitated on their upper edge, and at length are covered over, enclosing every impurity that may have fallen. It is obvious that metal so formed must be spongy and useless.

When the dissolving plate is downwards, the dense portions of the solution will subside to the lowest part of the cell, or remain in the hollows of the plate upon which it will crystallize, while the lighter, from its tendency to rise, causes a current to pass along the surface of the receiving plate, in the direction of its most elevated part, the course of which is marked by the dark colour of the deposit. If it meet with obstructions or hollows on the surface of the plate, it is retained, till reduced to that degree of density at which the granular or sandy deposit takes place; and if the solution should be disturbed before it has been observed, the loose grains are covered with the next quantity deposited, forming a porous or spongy part in the new plate, which, if near the surface, would render it unfit for engraving.

These evils may in some degree be diminished by slow deposit, the solution having greater time to mix. But this is insufficient to obtain the great desideratum of maintaining uniform density in the solution, and removing from contact with the receiving plate that portion from which a part of the metal has been precipitated before it is reduced to that state at which the brown or granular deposit takes place, that is, before the quantity of metallic particles in the solution is so reduced as not to be sufficient to engage all the current, and allow the water of the solution to be acted on.

The remedy for these evils is to be found in agitating the solution, and the result will be more evident with a battery of sufficient power to decompose water violently. In such a battery, if the plate to receive the deposit be suddenly plunged vertically, so as to produce as little movement as possible in the fluid, it will instantly evolve hydrogen, become coated with the dark brown deposit, and gradually covered with granular concretions; but if by some mechanical arrangement the solution be kept in constant agitation, or the plate kept in motion, the deposit will go down evenly, rapidly, and of good colour and consistence. After a small quantity has been de-

posited, the agitation may be less frequent; but if the plate be removed for a few minutes, and again immersed, the brown powder will again be thrown down unless the agitation be resumed.

Among other batteries, these experiments were made with one of Daniell's constant batteries in a series of ten cells, each exposing a surface of 36 square inches of positive metal; the surface of the receiving and dissolving plate being at first each 5 square inches, and subsequently the receiving plate reduced to 2 square inches, the dissolving plate remaining the same. The solution operated on was sulphate of copper acidulated, about one pint in a glass jar, the temperature of which, it may be remarked, was raised 45° in 30 minutes by the operation. The quantity deposited in 10 minutes was about the thickness of strong writing paper, perfectly solid, reguline, and easily removed from the plate.

From the above it would appear that with the same battery, the same solution, at various degrees of temperature, the receiving and depositing plates of equal or of different size, either of the characteristic deposits defined by Mr. Smee may be obtained, *provided the solution be kept in agitation, the receiving plate first immersed, and the dissolving plate inserted gradually.*

This branch of the subject has been dwelt on at somewhat greater length than would otherwise be necessary, because it occurs chiefly in large operations, and such are most likely to be used in the Engineer Department, whether as in the instances which have led to the present Paper, in the creation of duplicate copper-plates of considerable dimensions, or in the coating of metallic or other substances used in constructions, with a view to their preservation. To many such purposes there can be no doubt but electro-metallurgy will be applied. The science at present is wholly in its infancy, and in this notice little more has been attempted than to lay down a few general principles which will be found essential in all cases.

It has been proposed to perform the corroding process of etching by connecting the plate to be acted on with the positive pole of a battery, making it, in fact, a dissolving plate; from which various advantages may result in certain cases, as in diamond ruling, where it is desired to obtain a very smooth line, which engravers feel it difficult to obtain by the ordinary means, because the local action constantly produces irregularity, from the adhesion of bells of hydrogen to the sides of the line. This is wholly avoided in the voltaic operation, as the action takes place by direct combination of oxygen with the copper, but without the evolution of hydrogen, producing a line of equal depth, and giving to copper the exactness of steel.

When it is desired to strengthen the original work on a plate, *i. e.* to make the lines on the duplicate plate stronger than they were on the original, it may sometimes be accomplished by charging the old work with ink, and throwing down a thin deposit of copper, which will not settle on the ink, from its oily nature, then removing the ink in the ordinary way, when it is obvious the blank portions of the plate are raised; or conversely, the engraved work is deeper; and accordingly when the plate is again submitted to the process, the result will be a stronger work on the duplicate plate. To avoid all risk of adhesion and consequent injury to the original plate, it is desirable to take a facsimile duplicate in the first instance, and work upon that duplicate, leaving the original quite safe.

A new species of engraving has also resulted from it, and been practised in the Ordnance Survey Office, viz., ruling a plate all over carefully and taking duplicates from it, having first scraped from the matrix, after the manner of mezzotint, all the parts where lights are required. This is very applicable to engravings of towns, and probably to hills; to every thing, in fact, where an uniform ground is desirable.

It is needless to detail the numerous uses of this valuable art which are daily occurring.

It has also been used for copying scales and divided instruments, which will probably become a source of great economy,—a scale which costs several shillings being produced for a few pence.

Some very perfect casts of fossils were very early made by Mr. William Dalgleish; and while the Geological Survey was under the Ordnance a very elegant application of this power was effected by Captain James, R. E., viz., preserving the rare and unique specimens in the country where they are found, and depositing copies made by this process in other museums. Several very beautiful specimens were prepared under his direction for this purpose.

Description of Plate I.

Fig. 1. Original single cell apparatus.

2. Horizontal decomposing trough detached.
3. Two pairs of plates arranged for quantity.
4. Two pairs of plates arranged for intensity.
5. Pair of battery plates in the electrotype apparatus at the Ordnance Survey Office, Dublin.

Details.

A. Wooden frame for supporting the plates, which rest upon brackets fixed to the inside of the battery cell, at a sufficient distance from the bottom to allow space for the sulphate of zinc to sink below the plates.

B B. Plates of silver platinized.

C. Plate of zinc.

b b. Conductors from the silver plates, (negative.)

c. Conductor from the zinc plate, (positive.)

d. Connecting piece for joining the negative conductors, through which the positive conductor (*c*) passes.

e e. Conducting wires leading to the decomposing trough.

f f f. Copper bar, with prepared canvass straps for suspending the zinc plate between the silver plates, and keeping them at the proper distance asunder, which is withdrawn when the zinc plate is required to be removed for the purpose of cleaning, and to which is affixed an eye (*g*) for raising the whole frame and plates, when they are to be inserted into the battery cell.

h. Screw, with a similar screw on the opposite side of the frame, for the purpose of pressing the silver plates towards each other as the zinc grows thin.

Description of Plate II.

A. The battery cell, extending downwards 2 feet under the floor, and terminating in a point, in which a stop-cock is fixed, to draw off the saturated solution of sulphate of zinc, which is formed there. The bottom is reached by a trap-door and steps.

B. The decomposing trough, resting on a keel, which, for the purpose of agitating the solution, enables a rocking motion to be given to the trough, by means of a coupling shaft (*a*) connected with the truck (*b*) on which the trough is moved to any part of the room, for cleaning or changing the plate.

C C. Conductors from the battery plates, each formed of five lengths of copper wire $\frac{1}{10}$th of an inch in diameter, twisted together, and covered with water-proof tape, the one leading to the positive or dissolving plate (*c*), the other to the negative or receiving plate (*d*), the latter being placed on a board, with small feet or wedges, to keep it at the proper distance from, and parallel to, the positive plate.

D. A water-tight box containing a solution of sulphuric acid in the proportion of 1 to 4 water, by which the battery cell (having been originally charged with solution of the requisite strength, 1 to 30) is constantly supplied with renewed acid, through a lead pipe (*e*) which extends downwards into the cell about 2 feet, and is turned horizontally so as to cause a circulating movement in the solution. The box is provided with a float (*f*) to indicate the height of the acid solution in it, and the quantity which has passed into the battery.

N. B. In this Plate the acid box is placed near the battery cell for the sake of bringing it within the margin lines. It is nearly close to the ceiling, in reality, so as to afford by its height a considerable force to the solution issuing from the pipe, that it may circulate freely around the battery plates.

For want of height in this Plate, it has also been necessary to omit a beam which passes along the side of the room nearly close to the ceiling, on which a small carriage and pulley travel, for the purpose of raising the plates and moving them to any part of the battery range.

E. A gasometer, or gas collector, formed of thin copper, suspended by the wires (*g*) and the cord (*h*), which passes over the pulleys (*i i i*), and terminates in a counterpoise (*k*), intended to balance in part the collector, which is placed immediately over the plates in the battery, and dips into the solution. It is furnished with a stop-cock (*l*), through which the gas passes by the flexible tube (*m*) and copper pipe (*n*) to a gas meter (*o*).

F G. Levers, the former (F) being attached to the plug of the stop-cock, having at one end a weight (*p*) and at the other a chain (*q*) fastened to the battery cell; the latter (G) turning in the same centre, and brought by a screw (*r*) at one end into contact with the under part of the former (F), and kept in contact with it by the pressing of the weight (*p*). To its other end a small block of wood (*s*) is attached, dipping into a waste box (*t*), and acting as a weight when the box (*t*) is empty, and as a float when the box is filled by overflow from the battery cell.

H I. Levers, drawn downwards by the weight of the collector, with which they are connected by the cord (*u*). The former (H) turns on a pivot at the end of the latter, having at its other end a cord carrying a weight (*v*) which acts in the same manner as *s*; the latter (I) carrying, as before mentioned, the lever (H) at one end, and having at the other end a spring (*w*) screwed to it, from which a wire, passing through the lever, descends to the valve (*x*) for the purpose of raising the valve suddenly, being first closed upon the lever, until the adhesion of the valve to its seat is overcome, when the spring returns to its former position with a jerk, carrying up the valve, and opening the aperture at once to its greatest extent.

K. A lever fixed to the bottom of the box (D), having at one end a small hole through which the cord (*h*) passes, until checked by a knob (*y*), when the other end of the lever rises and lifts a valve (*z*) in the bottom of the box (*t*).

Working of the Apparatus.

The operation proceeds in the following manner. The aperture of the stop-cock (*l*) must be so adjusted by the screw (*r*) as to allow the gas evolved from the plates of the battery to escape at the same rate as that at which it is generated, allowing a slight excess to resist the uncounterpoised portion of the weight of the collector or

its tendency to sink down. Then, when the quantity evolved is greater than can pass through the aperture, the collector will ascend till the lever (F) is restrained by the chain (*q*), when the aperture will be enlarged till equivalent to the quantity evolved. On the contrary, when the quantity evolved is less than that for which the adjustment has been made, the collector will descend and pull down the levers (H and I); the weight (*v*) will resist the end of the lever (H), and the end of the lever (I) carrying the spring (*w*) will rise, and with it the valve (*x*) of the acid cistern, with a jerk; a quantity of the strong acid solution will then rush into the battery cell by the pipe (*e*), with sufficient force to circulate round the plates, displacing a portion of the lighter or less acid solution, which will run off by the overflow pipe (*o*) into the box (*t*), which thus becomes a measure of the quantity of acid thrown into the cell. When the lever (H) then becomes released from the weight of the float (*v*), the acid valve (*x*) preponderates, falls into its seat, and stops the supply. At the same time, the lever (G) of the collector is also released by the floating of the weight (*z*), and the aperture of the stop-cock completely closed by the weight (*p*). The gas collector in this condition rises rapidly, till the knob (*y*) comes into contact with the lever (K), when the valve (*z*) opens, and the solution in the waste box (*t*) runs into a vessel placed for its reception, where its deficiency of acid is supplied, and it again returned to the cistern (D). The waste box (*t*) being emptied, the floats (*s* and *v*) again descend to the bottom of the box (*s*), carrying down the lever (G), by which the aperture of the stop-cock is opened, and the apparatus is again in a position to throw in a greater supply of acid, if the energy of the battery is not sufficient to evolve the quantity of hydrogen for which the aperture has been adjusted. Thus the *power* of the battery depends on the stop-cock, whose normal position is adjusted in the first instance to the required openness by the screw (*r*); and the state *of its working* is ascertained by the quantities of gas which pass through the meter in equal times.

EXPLOSION OF POWDER.*

Voltaic Blasting is the method of firing gunpowder by the transmission of a current of voltaic electricity through a complete circuit of metallic wire, or through a circuit which may be partly composed of water, according as the operation is to be performed on land or under water.

The principle depends on the property of the electric current to raise the temperature of the wire or other metal through which it passes: hence the required object is to adopt such an arrangement, as that a small portion of the circuit may be rendered red hot at the proper place, *i. e.* within the powder composing the charge.

This object is attained by employing a voltaic battery of sufficient intensity to heat a short length of fine steel or platinum wire fixed across the disconnected ends of the conducting wires within the powder: upon this *intensity* of battery depends the power of the current to overcome obstacles or to travel the required distance to produce the proper effect. The wires must also be of adequate thickness, for their conducting power varies with this, or with the area of their section. The principle of voltaic action may be thus briefly stated. Let fig. 1 be a glass vessel containing a

* By Capt. Hutchinson, R. E., May, 1845.

liquid and a plate of copper (C) connected with a plate of zinc (z), constituting a pair of a voltaic pile.

When the liquid is water alone, there is scarcely any electrical action. When salt is added, the action becomes evident; but when sulphuric acid is added, it is very greatly increased: a decomposition of the fluid in this case takes place; the oxygen is taken up by the zinc, which has the greater affinity for oxygen, and is therefore called the positive metal; the hydrogen is evolved at the negative metal, copper. A current of electricity is thus generated.

Several positive and negative plates immersed in an acid solution, and connected one with the other in a series, constitute a voltaic battery, which is more or less intense, according to the number of plates.

Various forms have been given to the voltaic battery, and modifications made from time to time, according to the purposes to which it was to be applied.

DESCRIPTION OF BATTERIES THAT MAY BE EMPLOYED IN BLASTING.

Copper and Zinc Plate Battery.

The common copper and zinc plate battery on Dr. Wollaston's principle may be thus described, being similar to those used in the explosion of the mines at the Round Down Cliff, Dover, and in the last summer-operations of 1843, on the *Royal George*, at Spithead. The pairs or sets of plates composing the series are each composed of a zinc plate $\frac{3}{16}$ inch thick in the centre of a rectangular case of sheet copper, without top or bottom, a convenient size for which may be 10 inches long, $1\frac{1}{8}$ inch wide, and 8 inches deep. The zinc plates must be about $\frac{3}{4}$ inch shorter than the copper case, so that the edges of the metals may not be in contact: two slips of wood with grooves in them should be fixed, one down the inside of each end of the copper case, and nailed by small copper nails: the zinc plates will then slide up and down in these grooves, which will be found convenient in withdrawing them for cleaning, and will keep them separate from the copper. The connections may be formed by bands or strips of stout sheet copper $\frac{1}{2}$ to $\frac{3}{4}$ inch wide, riveted to the zinc plate, and soldered to the copper case: there should be two connections to each set of plates, fixed at a few inches from their ends. Binding screws should be used for connecting the strips of metal in sequence above the plates thus: let the 1st zinc form the terminal plate or negative pole of the battery: this must be disconnected from any other: the two strips of metal on the 1st copper case will then be turned over, and connected with the two on the 2nd zinc plate, the two on the 2nd copper with the two on the 3rd zinc, the two on the 3rd copper with the two on the 4th zinc, and so on up to a series of ten or twelve, which will be found sufficient for any common mining purposes. The last copper case will then be found to stand free as a terminal plate or positive pole. Two stout copper wires, let into these terminal plates, will form the poles, on connecting which the circuit is complete. The sets of plates must all be let into a stout frame 2 inches × $1\frac{1}{2}$ inch, for the purpose of immersing the whole simultaneously into the trough or cells containing the acidulated solution, which should consist of dilute sulphuric acid, in the proportion of 1 of acid to 10 or 12 of water. This trough should be either of oak or elm baked, as it then becomes a very imperfect conductor of electricity. There must be as many cells as sets of plates, which should be from $1\frac{1}{2}$ inch to 2 inches wide, and 9 inches deep. The partitions separating them should be about $\frac{1}{2}$ inch thick; the whole made water-tight by being coated with a cement, for which the following ingredients have been found by trial to answer the best, viz.

Spirits of wine	½ gallon.
Shell-lac	½ lb.
Gum Sandarach	2 oz.
Vermillion	¼ lb.

The above quantities and proportions will be found sufficient for covering the inside of the trough of a battery of 10 cells with 2 coats, containing about 23 superficial feet each.

The partitions to the cells are necessary in a battery of this form, to keep each set of plates separate, otherwise the fluid acting as a conductor would cause a cross play of electricity between every positive and negative plate in metallic connection, and much power would be lost.

In lieu of the connections by bands or strips of sheet copper, a convenient form of uniting the copper case and zinc plate will be by leaving a tongue or flap projecting from one of the upper edges of the former, and extending its whole length, sufficiently broad to be turned over at right angles, and again bent upwards so as to come in contact with the adjoining zinc plate: the whole of the upper edges of the two metals will thus be in metallic contact, by which increased contact some additional power will be gained: in this arrangement the zinc plate must stand higher than the copper case by about ¾ of an inch, so that the flap of copper may be quite clear of the case next to it: the end or terminal plates may be finished with triangular flaps, and the wires for forming the poles may be connected to the apex of each triangle.*

This constitutes a common plate battery, which, for mining operations, will be found sufficiently powerful from the very short time required to keep it in action for heating platinum wire. But it has many defects. The acid speedily becomes saturated with oxide of zinc, by which its conducting power is reduced. The hydrogen which is set free at the negative copper plate adheres with great tenacity to its surface, and throws a considerable portion out of action: it reduces the zinc from the solution, and deposits it on the copper plate, by which a zinc plate is virtually opposed to a zinc, and a counter-action is thus produced; and in addition to this, the zinc of commerce, being exceedingly impure, contains many particles of foreign matter which unite in consuming the zinc, and in causing what is called *local action:* this latter evil is however somewhat obviated by the amalgamation of the zinc plates with mercury.

Professor Daniell's Constant Battery.

To remedy many of the defects of the common plate battery, Professor Daniell contrived an ingenious arrangement, which has been termed the *constant battery.* A single cell of this battery consists of a copper cylinder, an amalgamated zinc rod, and a porous diaphragm, which may be composed of various materials, such as paper, plaster of Paris, sail cloth, porous earth, or animal membrane: the latter has always been used in the operations of the Corps of Royal Engineers, and was preferred by Professor Daniell. In this arrangement two fluids are used, separated by the diaphragm, containing dilute sulphuric acid in the proportion of 1 of acid to 8 of water, in which the zinc rod is immersed: on the outside of the diaphragm, next the copper cylinder, is a saturated solution of sulphate of copper, containing a little sulphuric acid: binding screws and stout wires are used to connect the respective metals with

* This last arrangement appears to be unnecessary,—the usual "connections by bands or strips of sheet copper" being quite sufficient.—*Ed.*

each other. The zinc being well amalgamated, and the apparatus in perfect order, no electrical action will take place until the circuit is completed by the wires, when it will be indicated by a sharp and clear spark emitted at the poles: this action, however, takes place without the evolution of hydrogen at the negative metal;—in lieu of this, copper will be released from its sulphate, and deposited on the copper cylinder; the strength of the solution must therefore be kept up by a supply of the crystals of the sulphate of copper, which should be continually dropped in for the purpose of being dissolved. The advantages of this arrangement are, that the hydrogen, not being evolved at the copper cylinder, the formation of the film or coating of this gas is avoided, which has been shewn to be so prejudicial to constancy of action in common plate batteries: on the contrary, a deposit of pure copper is formed, and the deposition of zinc upon the copper is avoided. The limits of the duration of the action are, the exhaustion of the copper solution, and the saturation of the acid solution within the diaphragm, joined to the consumption of zinc. The action may be prolonged for a very long period (8 or 10 hours).

Professor Daniell's battery was the one used by Major-General Pasley during the first four seasons of his operations against the wreck of the *Royal George*, at Spithead, and previously in the demolition of two wrecks in the Thames. During the experiments carried on in the winter of 1842-3, at Dover, previously to the explosion of the great mines at the Round Down Cliff, these batteries were tried to a great extent (as many as 50 cells having been constructed): they, were, however found capricious and uncertain, and frequent failures ensued in the experiments, which could not at the time be satisfactorily accounted for: their power was also much influenced by the low temperature of the season, and it at length became necessary to keep them close to large charcoal fires to produce any thing like a proper degree of action: the manipulations required in connecting so many cells became also very troublesome and tedious, and the ox-gullet diaphragms were difficult to procure. The common plate batteries already described were therefore tried and preferred, being more powerful for the time their action lasted, and requiring comparatively little trouble, either for their construction or management.

During the last season's operations against the wreck of the *Royal George* (of 1843), which brought this interesting work to a close, it was found necessary to fire several large charges simultaneously, which was accomplished by the aid of plate batteries, composed both of zinc and copper, and of zinc and iron; and here their superiority in power and facility in manipulation were again evident. Professor Daniell's arrangement is therefore chiefly valuable for all purposes where much constancy of action is required, and is indeed very useful in blasting operations. But it will not be found of such general practical utility as the combination of plates already described.

It will now be shewn that iron, as the negative metal, possesses some advantages over copper for plate batteries.

Of the Zinc and Iron Plate Battery.

Within the last few years, iron has been much used in Scotland as the negative metal for plate batteries. Its being more economical than copper was probably the principal reason for its being first adopted, but it is also superior in other respects. When the battery is in action, the hydrogen of the decomposed fluid does not adhere to the surface of iron as it does to copper, which has already been shewn to cause great loss of power. Mr. Grove supposes that the fact of iron decomposing water is the cause of this—1st, the oxidation roughens the surface of the plate; and 2nd, it continually breaks up and carries off any film of hydrogen, sub-oxide of zinc, or metallic deposit of zinc, which would otherwise present an opposing force; and it is

generally observed that roughened surfaces throw off gases better than smooth ones. Iron therefore becomes a better material for a battery than copper, inasmuch as a considerable constancy of action is preserved, though for the first few seconds, copper, as the better conducting metal, would be superior in energy, until its effect is weakened by the adhesion of the hydrogen: this has been shewn in many experiments with the voltameter, where the mixed gases were delivered in a much greater (nearly double) volume from a zinc and iron, than from a zinc and copper battery, when the action was continued for any lengthened period. Either cast or wrought iron plates may be used, but the former are found rather more powerful. This may be owing to cast iron having a rougher surface, and being rendered more unoxideable by the carbon it contains. Plates may, however, be more easily formed out of wrought or sheet iron.

The common arrangement of a battery of this form would be similar to the Wollaston's, viz., a single zinc between two iron plates: ten or twelve of these sets would be sufficient for a battery for common purposes. The iron plates should be cast as thin as possible, to diminish the weight; $\frac{3}{16}$ths of an inch is a good thickness. The connections of the battery may be formed by strips or bands of sheet copper, $\frac{1}{2}$ to $\frac{3}{4}$ inch wide, riveted to the iron and zinc plates, one on each of the former, and two on the latter, connected by binding screws: to observe regularity in forming the connections down the series, and to avoid confusion, the width of the battery should be divided into five equal parts; then the connections of the first set of plates may be riveted to them, at the first and third divisions; of the second set, at the second and fourth divisions; of the third, at the first and third; and so on alternately: this will preserve regularity, and keep all connections clear of each other. This difference in connecting the copper and iron plate batteries is caused by the former being one single case, the latter two separate plates, each of which has to be connected to its adjacent zinc.

A convenient dimension for the plates will be about $10'' \times 8''$; they should all slide in grooves, cut out of upright pieces of wood let into the frame: any plate may thus readily be withdrawn, if required. The plates should be supported by leaving about $\frac{1}{2}$ an inch at the bottom of each groove solid or uncut, which will form a shoulder for them to rest upon, and they will thus be about $\frac{1}{2}$ an inch clear of the bottom of the trough.

The acid solution should be of the same strength as for the copper plate battery already mentioned.

The dimensions of the trough for a battery of ten sets of plates will be about $2'\ 2'' \times 1'\ 1'' \times 10''$, each cell being $11\frac{1}{4}$ inches long, 2 inches broad, and 9 inches deep.

A plate battery should always be raised or suspended above its trough when not in action, to allow the acid solution to drip from the plates into the trough; and this may be done in various ways, either by having ends or handles projecting beyond the frame for lifting the battery in and out, or by standards attached to the ends of the trough, carrying a windlass, with handles for winding the battery up and down by means of a cord attached to each end of the frame; and which may be rendered still easier to work, by having weights to counterbalance the battery suspended over small pulleys on the standards, when one person may work the battery with ease; or, lastly, by having a cog-wheel and rack inserted in each end of the frame, with handles for turning the wheels. The battery will thus be raised and lowered without having so much additional apparatus. Perhaps of all these methods the plan of counterbalancing the battery may be considered the best, as affording the greatest facility for working.

A plan for constructing the iron and zinc battery has lately been adopted in Scotland, which possesses some advantages over the one above described on the Wollaston principle, in which the trough is simply a box without partitions: a battery on this principle becomes very compact, as the plates may be much closer to each other than in any other arrangement: the action of both sides of the plates is also thus obtained. In this construction the zinc and iron plates are placed alternately, in lieu of having one of the former between every two of the latter: supposing the series to commence with iron, let the first and second iron plates be connected together as a double terminal plate, with a wire attached to form the positive end or pole; then join the first zinc and third iron, the second zinc and the fourth iron, the third zinc and the fifth iron, and so on to the end of the series, which may consist of twenty plates of zinc and twenty-one of iron; then it will be found that the twentieth or last zinc will be disconnected from any other, and a wire attached to this will form the negative end or pole.

In this construction the plates may be very close to each other, about $\frac{1}{4}$ of an inch apart; they should be separated by slips of wood of this thickness, placed between each plate, the whole being kept together by two pieces of board at the ends, connected by cross bars at the sides, and with one at the bottom to prevent the plates from falling out: this arrangement will be found simple and expeditious, and therefore well calculated for common blasting operations. The partitions in the trough may be dispensed with, because by the method of connection, two plates intervene between every pair in metallic connection; there is thus no cross play of electricity, which would ensue with a battery on the Wollaston arrangement, if immersed in a trough without partitions. The action of both sides of the plates is also thus obtained. A battery of twenty pairs, or of forty-one single plates, may be readily got into a space of 20 inches in length, or even less.

This last mode of arrangement is recommended for blasting operations in the field, from its compactness and simplicity of construction: the power of a battery of this form would be about on an equality with one of a similar number of plates on the Wollaston principle, and a single battery would be sufficient to fire charges at the distance of 500 feet: if more power should be required, then two of them may be combined.

Professor Grove's Battery.

The battery possessing the greatest known intensity is of the form invented by Professor Grove: its peculiarity consists in the use of two acids,—concentrated nitric and dilute sulphuric or muriatic: the former is contained in an inner porous cell in contact with platinum, the negative metal; the latter in an outer vessel with zinc, the positive metal. As soon as the electric current is established by completion of the circuit, both acids are decomposed; the hydrogen of the muriatic unites with the oxygen of the nitric, and the chlorine attacks the zinc. The hydrogen is thus removed without being evolved at the negative plate. Its superior energy, as compared with Professor Daniell's battery or with the common arrangement of plates, is due to the nitric acid parting with its oxygen more readily than sulphate of copper; resistance is thus lessened, and its power relatively increased: there is also no precipitation either of copper or zinc on the negative metal, and, consequently, no counteraction.

This battery is remarkable for its power: a series of four cells in good order will give a cubic inch of mixed gases per minute for every square inch of platinum in each cell, and all the other effects in proportion. It has also the advantage of occupying very little space. It is remarkably constant, and, from its great intensity, very

economical, as a smaller series may be employed than in any of the other combinations.

For mining and blasting operations on a large scale, its great intensity would make it valuable, particularly in firing a number of charges simultaneously; but for common purposes of this kind it would perhaps not be so practically useful as the simpler form of the zinc and iron battery already mentioned, the porous cells being fragile and delicate, and the nitric acid destructive to clothing. Its construction might, however, be modified to remedy these inconveniences, and to make it practically useful in the field.

Smee's Battery.

Another battery of great practical utility has also been invented by Mr. Smee, who has taken advantage of the property which roughened surfaces possess of evolving the hydrogen, by covering the negative element, either silver or platinum, (generally the former for practical purposes,) with the finely divided black powder of platinum: it is not, however, considered necessary to enter more fully into the construction of this battery. Compared with Professor Grove's, its relative power is, Smee's 59, Grove's 75, as indicated by the number of degrees of deflection of the galvanometer.

The principles of six several kinds of batteries which may be usefully employed in blasting having been given, it should be again remarked that the cast iron and zinc battery will be found the most practically useful, and the simplest form will be that described in page 391, in which the zinc and iron plates are placed alternately, and the action of both their sides is obtained; the trough being simply a box, without being divided into cells.

OF THE CONDUCTING WIRE TO BE USED IN BLASTING.

The best and most convenient form of conducting wire consists of several fine copper wires twisted together like a hempen rope: thus prepared, it becomes very flexible, and less liable to break than a solid wire of equal dimensions, which has generally been used in the operations of the Corps: the junctions of the several lengths may be very securely united by splicing, as in a common rope: with the solid wire these joints are difficult to form, and a fracture is more liable to occur at a joint than at any other part. Fine wire can always be procured, whereas it would probably be necessary to have a solid wire of sufficient size manufactured for the purpose.

It has already been stated that the conducting power of wires varies with their thickness, or with the area of their section: this should not be less than $\frac{1}{5}$th or $\frac{1}{6}$th inch in diameter, and in forming the wire rope as many fine wires must be twisted together as will make up this size. During the last season's operations on the wreck of the *Royal George*, the wire rope was prepared in the rope-house at Portsmouth Dockyard out of wire $\frac{1}{10}$th inch in diameter, or No. 14 guage; three strands or threads being a little more than equivalent in area to one solid wire $\frac{1}{6}$th inch in diameter: 30 ℔s. in weight of this size, or 1000 feet in length, made 300 feet of conducting wire when completed.

To insulate or separate the two conducting wires from each other, which for the sake of convenience and portability should, in land operations, be laid close together, so as to form, as it were, one rope,—they must be carefully coated with a water-proof composition, and then bound over with layers of tape, twine, &c., making them, when thus prepared, about $\frac{3}{8}$th inch in thickness. The composition which has been hitherto generally used for this purpose consists of bees'-wax, pitch, and tallow, in the proportion of 8 pints of pitch to 1 of each of the other ingredients, laid on while hot: it is probable, however, that sheet India-rubber, bound over the

wires and covered with India-rubber solution, would effectually insulate them, defend them from damp when laid in moist ground, and be more cleanly than this composition, which, as to its proportions, was the result of many trials made by Serjeant-Major Jones, R. S. & M., at the Royal Engineer Establishment, Chatham.

In forming conducting wires, they have hitherto generally been separated or insulated by being laid on each side of an ½-inch rope placed between them, which has been considered necessary for perfect insulation. This rope may, however, be dispensed * with, and for land operations, the wires having been carefully coated in the manner described, may be laid close together, side by side, and then bound over or connected by coarse tape or twine. The double conductor thus becomes small and of convenient size, and may be coiled on a common log reel, whereas with the addition of the rope it becomes bulky, and a large drum is then necessary for coiling it flat and free from kinks.

For subaqueous operations, in using a double wire it will be better that the two wires thus prepared should be employed separately † or singly rather than joined together as one; for in working under water much inconvenience and loss of power result from the covering becoming gradually worn off by damp and friction, leaving the wires exposed in one or more places and in contact with the water, and failures are frequently caused from the wires being brought together at an improper place, causing the circuit to be completed before arriving at the charge. This is more especially the case when they are separated by the rope, which in contracting by the penetration of moisture would draw up the wires over it, and cause them more quickly to come in contact. The two separate single lines may each be connected to one of the priming wires of the charge at one end, and to the poles of the battery at the other, and a large space left between them intermediately; then all risk of a failure from improper metallic contact would be obviated.

But in subaqueous operations, a complete metallic circuit is not required; a portion of one of the conducting wires may be dispensed with, and the depth of water intervening between the charge at the bottom and the surface of the sea or other piece of water in which the operations are being carried on, may be used for completing the circuit. In this case, on account of water being a more imperfect conductor than that portion of the wire for which it is substituted, it becomes necessary to use a larger surface of metal at each extremity of the water conductor, that is to say, (in the case of submarine operations,) at the bottom and surface of the sea, to lead the electric fluid through it. At Spithead, in the summer of 1843, we used zinc plates at the surface, and the case of tin or iron in which the charge was usually contained served as the metal required at the bottom. At the depth of 13 fathoms it was ascertained that about 3 square feet of surface of the zinc or positive metal was required, but in respect to the other, or negative metal, a much smaller surface was apparently sufficient. This surface of zinc should be divided into three or more plates, connected with each other and suspended from a copper wire passed through a hole in the top of each plate, and immersed into the water at the surface: the other end of this wire goes to the battery. The long single wire extending from the battery to the charge is connected to one of the priming or short wires inserted in the bursting tube, and the other priming wire is turned down on the metallic surface of the case enclosing the charge, and connected with it. The charge having

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* It was dispensed with by Capt. Larcom, R. E., in the Phœnix Park operations, December, 1843. *Vide* Corps Papers, vol. ix.—*Ed.*

† Two separate wires were used by Major-General Pasley in working over the wreck of the *Edgar*, at Spithead, during the summer of 1844.

been taken down by a diver, and placed in its proper position at the bottom, the ends of the long single wire above water, and of the short length attached to the plates, are led to the voltaic battery; on forming contact at which, the intercepted portion of the circuit from the zinc plates at the top to the metal case at the bottom of the sea is completed by the depth of water between them: the electric current is thus passed through the piece of fine platinum wires fixed across the priming wires of the bursting charge, which also forms a part of the circuit, and is instantaneously ignited. This method will serve when the charge is contained in a vessel of tin, iron, &c.; but in the case of wooden casks it would be necessary to attach a sheet of tin or copper to the surfaces of the cask, to which the second priming wire would be attached.

DESCRIPTION OF THE CHARGES USUALLY EMPLOYED IN VOLTAIC BLASTING.

It has already been stated that ignition is communicated to the charge by having a small portion of the circuit within the powder, composed of fine steel or platinum wire (about 1 inch in length), which, being made red hot during the transmission of the voltaic current, fires the charge as soon as contact is made at the battery.

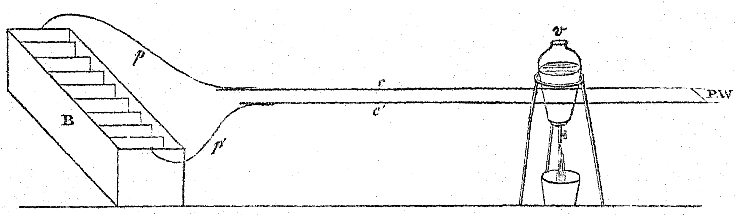
From the rapidity with which the fine wire is fuzed, it is necessary that the powder immediately in contact with it should be of a finer quality and more thoroughly dried than the main body of powder composing the charge. On this account, and for the sake of convenience in attaching the main or conducting wires, it is usual to have small bursting charges, or cartridges, holding a few ounces of the finest sporting powder, (their size varying according to that of the mass of powder to be ignited,) which should be thoroughly dried by being placed and shaken on a plate which has been moderately heated at the fire. These bursting charges may be contained in cylinders or cases of tin or paper; if in the former, great care is required to prevent the wires within the case from touching the tin, on account of its being a conductor. For land operations, it will merely be necessary to close the top and bottom of the bursting charge with bungs of cork; before fixing which, the priming wires (so called to distinguish them from the main or conducting wires) should be introduced, from a foot to 18 inches long, the ends projecting 9 or 12 inches from the top of the case, the ends within it passing through grooves cut into the sides of the upper cork, and clenched against a thin piece of wood near the bottom of the bursting charge, but not occupying the whole of its interior space. The platinum wire should be fixed across the copper wires about the centre of the bursting charge, which should then be filled from the bottom with the finest sporting powder (thoroughly dried as above described), and closed by the lower bung of cork. The top and bottom of the bursting charge should then be sealed with any good cement, which does not crack in cooling, and will keep out damp.

In firing a mine on land, it will be necessary to place a bursting charge, prepared as above, in the centre of the mass of powder to be ignited; the ends of the main conducting wires must then be connected with those of its priming wires by placing a few inches of each, side by side, and frapping round them with fine bell wire, and then covering them with tape dipped in water-proof composition. The length of the conducting wire must of course vary according to the nature of the mass to be removed by the explosion, the splinters from which, if of rock, might endanger the operator at the battery, unless at a considerable distance from the charge. In mining operations on a moderate scale, a length of from 300 to 500 feet will generally be found sufficient for conducting wires, and for which the battery of ten sets of plates will possess sufficient energy. Contact may then be made at the battery by hand; and from the known rapidity with which electricity travels, the time which it takes to pass through this length of wire will make no perceptible difference in that

of firing the mine, which may be said to take place at the instant the circuit is completed: should it be feared, however, that at this distance splinters might injure the person firing, a self-acting apparatus may easily be contrived by which he may retire to a place of safety, after having made the arrangements at the battery to insure the circuit being completed a minute or two after he has left it.

Such a self-acting apparatus may be formed by means of mercury in a cup or vessel having one end of the conducting wire dipped into it, while the pole of the battery to which it is to be connected is suspended above it, and held by a string; (the end of the other conducting wire and pole of the battery having been previously connected.) If such an arrangement therefore is adopted as to cause this string to be burned asunder in a given interval after the operator has left the battery, so that the pole of the battery may drop into the same cup of mercury as that in which the end of the conducting wire to which it is to be connected is already immersed, the object is gained; for by means of mercury as good a connection is formed as if the ends of the wires actually touched each other.

Another method by the agency of mercury has been recommended by Professor O'Shaughnessy, thus:



c, c'. Conducting wires.
P. W. Platinum wire.
p, p'. Poles of battery B.
V. Vessel filled with mercury, and with a cock at bottom for emptying it: the conducting wires (*c, c'*) pass through holes in the sides of the vessel.

As long as the vessel is full, the circuit of the conducting wires will be completed by the mercury, and the electric current will thus be stopped from passing through the piece of platinum wire (P. W.); but on opening the cock below, the mercury will descend, and as soon as a sufficient quantity has run out to leave the conducting wires clear, the current will no longer be stopped, but will pass through the secondary wire (P. W.) and ignite it. Therefore a sufficient quantity of mercury should be left above the level of wires (*c, c'*) to allow a person time to get out of danger, after having turned the cock and made the arrangements for firing the charge.

Mr. Roberts has recommended another mode of producing contact by means of a string to be pulled by the operator when out of danger, which causes a tin disc to move along a cross bar fixed on two uprights at the ends of the battery, and to come in contact with another tin disc fixed on the same cross bar: by previously attaching those wires to the discs, which would otherwise have been connected by hand, it is plain that the contact of the discs will cause that of the wires: the discs should be kept apart until required for use, by means a spiral spring attached to one of them, and coiled round the bar, which, when extended, will allow them to be in contact, but when the string is slackened will cause them again to separate by coiling up. The operator may thus retire to a considerable distance, taking care that the battery is in such a position as not likely to be injured by falling fragments of rock; and on pulling the string, and bringing the discs into contact, the explosion of the mine will ensue.

For blasts in rock, General Pasley has recommended cones, either of iron or hard wood, being used immediately over the bag or case containing the powder, (for voltaic purposes, iron will be objectionable, and wood only should be used;) the upper part of the hole to be filled with small pieces of hard broken stone, capable of being passed through a ring of about ¾ inch in diameter, which will answer the purpose of tamping. In preparing these blasts for being fired by the voltaic battery, the priming wires should be let through a groove cut on each side of the wooden cone, their ends turned down on the bottom of it, and connected by a piece of fine platinum wire from 1 inch to 1¼ inch long. If in a dry soil, the powder may then be enclosed in a canvass bag, tied round a projecting collar on the bottom cone; the cone and the charge with its priming wires may thus be let down to the bottom of the hole, and the tamping of broken stone made over it. The priming wires will, of course, vary in length according to the depth of hole; they should project about 12 inches above the top of it, and the conducting wires may then be connected to them, as above described. If in a damp or wet situation, the bag must be coated and made water-proof, or the charge may be contained in a case of brown paper or pasteboard, pitched over.

For mines of a moderate size, which do not contain more than from 50 to 200 ℔s. of powder, the bursting charges may be small; the cartridge being altogether about 4 inches long and 1 inch in diameter, and holding about 1 oz. of fine powder.

In operations on a larger scale, these secondary charges may be proportionably increased in size, and even two may be used on each conducting wire, to be fired simultaneously, so as to ignite a large mass of powder in two places at the same instant: this was successfully adopted in firing the great mines at the Round Down Cliff, Dover, in January, 1843, where for the three charges (two of 5500 ℔s. and one of 7500 ℔s.) there were two bursting charges on each conducting wire, 9 inches long and 2 inches diameter, which were extended to a distance of about 3 feet apart in the chambers, and buried in the centre tier of loose powder. In this operation the powder was contained in loose bags, holding about 50 ℔s. each, the mouths left open, and uppermost in the tiers below the centre, while those above it had the mouths downwards: the interstices were filled in with loose powder. This will be found a convenient mode of charging mines, and will insure the ignition of the whole of the powder when in large masses.

ON THE PREPARATION OF CHARGES FOR SUBAQUEOUS OPERATIONS.

The preparation of these charges requires the greatest care, particularly when the operations are carried on at any great depth.

In working against a wreck, the general system will be to employ large charges at first to break it up into detached masses, which if necessary may again be subdivided by using charges of a smaller size, until at length very small quantities of powder will be sufficient to break up or detach the pieces still remaining. Hence the sizes of the charges will vary according to the objects for which they are required. For containing the larger charges, which are supposed not to exceed 600 or 700 ℔s., wine or spirit casks will be found convenient and economical; and if the depth does not exceed 30 or 40 feet, they need not be stronger than those commonly used in the Royal Navy, excepting that the heads will require some additional security, as being the part most liable to be forced in by the pressure of the water. Beyond that depth, however, the whole cask should be more strongly made than would be usual for common purposes.

A convenient size of cask for the larger charges will be the 72-gallon puncheon; for the medium size, the 18-gallon kilderkin; and for the small ones, tin cans or oil

bottles, of sizes varying from 2 to 5 gallons, many of which are usually in store at the different stations, and thus easily procured.

The puncheon for the larger charges, when sunk to depths of from 10 to 12 or 13 fathoms, should be prepared as shewn in Plate VI.; the body or staves to be $1\frac{1}{2}$ inch thick, and the heads formed in two thicknesses of $1\frac{1}{4}$ inch each, the lower one placed transversely to the upper, and resting on a circular groove or shoulder cut out all round the inside of the ends of the staves, equal in depth to about half their thickness: this lower head should be additionally secured, both at top and bottom, against external pressure, by the support of four cleats, to be let at equal distances round the circle about $\frac{1}{2}$ inch into the thickness of the body. The upper head should be fixed close over the lower one, and secured to it by strong 3-inch screws; it should come flush with the outside of the cask, and a broad iron hoop passed round outside the top and bottom, screwed to each of the heads, will secure and connect the whole firmly together. Where these or similar precautions are not adopted, there would be every probability of the heads being forced in by the pressure of water above, which, on a head 2 feet in diameter, at the depth of 13 fathoms, would be about 7 tons.

In altering common puncheons for subaqueous explosions, such as could generally be procured in a colony from the Commissariat Department, it would be necessary to saw off so much of the top and bottom as would include the triangular groove or mortise into which the common form of head is usually let; then the rebate or shoulder for the new head should be commenced from that level.

The most difficult and troublesome part of the operation will be that of making the cask water-proof; for when sunk to a great depth, the pressure of the water would cause it to penetrate at the most minute hole or imperfection in the covering. The cask is first to be payed over with a coat of the composition above mentioned, consisting of bees'-wax, pitch, and tallow, which will fill up the pores of the wood, and, with the addition of strips of canvass laid between the hoops, will bring the whole surface level, and prevent their edges from chafing the coats of canvass to be next laid on, which should consist of strips (No. 6, good old worn canvass will do) laid on lengthwise, from end to end, having been previously coated with composition on the under side only: the ends projecting 5 or 6 inches beyond those of the cask should be notched for the purpose of folding or plaiting down upon the circular heads: the joints of the canvass should not lap over each other, but merely touch; 5-inch slips are to be laid over each joint previous to the second coating, in which the canvass should be laid in a transverse direction to the first, encircling the cask with one joint round the centre or bung diameter, and projecting 4 inches over the ends, which projections should be notched and plaited down on the heads as before. A 5-inch strip must then be laid over the central meeting joint, and each head covered with a circular piece equal to its own diameter.

In both first and second coats, the composition should be laid on the under side of the canvass only, and drawn through to the upper one by a hot flat iron: by this means the interstices and pores of the canvass are entirely filled, and made water-proof. A coating of the composition should also be put over the whole on completion.

When in this state, the puncheon should be lowered empty to the depth at which the charge is intended to be fired, in order to test its strength and water-proof qualities; and if proper precautions have been taken, the cask will not admit the smallest particle of water. It should be kept immersed at the proper depth for about half an hour, and a heavy weight, such as a 10-cwt. anchor, will be required to sink it, and overcome its buoyancy: in lowering, it will be necessary to protect the canvass

covering from friction of the slings in which it is held, by fixing six or eight staves of casks tightly round the outside, lashing them at equal distances by yarn, for the reception of which, grooves should be cut in the staves, about 2 inches wide and $\frac{1}{2}$ inch deep, at about 6 inches from each end. The slings may then be passed over the staves, and kept quite clear of the water-proof covering, and they should also be connected by rope-yarn to keep them from slipping. After the cask has been drawn up, if found to be water-tight, it will be ready for loading and for the insertion of the bursting tube, which may be conveniently formed out of lead pipe, with the bottom closed, and a circular collar or flange formed on the top, projecting about $\frac{1}{2}$ inch, for the purpose of nailing on to the cask. The length of the tube should be a little more than half the bung diameter, so as to enter the cask to about half its depth. For the 72-gallon puncheon, a convenient size of tube will be 1′ 6″ long and 2 inches diameter; and for the 18-gallon kilderkin, 12 inches long and $1\frac{1}{2}$ inch diameter: a circular hole must be cut out of the cask, at its bung diameter, of sufficient size to receive the tube which will be inserted, and the projecting collar nailed down on the surface by small clout nails. The operation of loading may then be commenced: the loading hole will be cut out of the centre of one of the heads, tapering from the top to the bottom, where it should be about 2 inches diameter; a cleat 20 inches long and 4 inches broad having been previously nailed on over the centre of the head, which will thus make the thickness of wood at the loading hole about $3\frac{1}{2}$ inches. The puncheon should be filled by inverting the small powder barrels (holding 90 lbs. each) over the loading hole: as each barrel-full is poured in, the puncheon must be continually shaken, in order that the powder may be properly distributed over the whole surface, and it should at the same time be rammed by a copper rammer. Nearly 10 lbs. of powder per gallon may thus be got into the puncheon: as soon as it is full, a small wooden plug, about an inch thick, should be dropped into the bottom of the loading hole, and the water-proof composition poured in above it, until nearly on a level with the top of the upper surface of the head: the remainder of the hole within the cleat will then be closed by a dovetailed wooden plug, with a circular head projecting about $\frac{1}{2}$ inch all round, firmly driven in with composition, and just entering the upper part of that already poured in; the whole should then be carefully payed over with the same: this mode of forming the loading hole has been found to answer admirably.

The preparation of the bursting charge will be similar in principle to that already described for land operations, though differing somewhat as to its details: it is shewn in Plate VI., where *a* and *b** represent a collar and plug, which may be turned out of oak, elm, or beach. The collar is for closing the top of the tube, into which its lower half should enter about half an inch, being made a little smaller than the diameter of the tube, while the upper half lies on the surface of the cask, consisting of a flange or shoulder projecting half an inch all round. A circular hole is left in the centre of the collar, about $1\frac{1}{4}$ inch diameter, through which the two priming wires pass, and their ends are received by the plug below, which should be of a cylindrical form, varying in size according to that of the bursting charge: for the 2-inch tube the plug should be about $1\frac{1}{2}$ inch diameter and 7 inches long, with two grooves $\frac{3}{8}$ inch square, cut in it opposite to each other, in which the wires are laid: the lower part of the plug should swell out about half an inch for 1 inch in length, to give a projection for attaching the mouth of the canvass bag containing the bursting powder. The ends of the priming wires are turned up and flattened against that of the plug, and nailed to it with small copper nails: two pieces of fine platinum wire are then to

* These references are omitted in the original drawings, but evidently relate to figs. 1, 2, 5, 6.

be laid across the ends in small notches previously cut into them with a chisel, which should be closed and hammered lightly down over the fine wire to retain it in place. This operation requires great care from the delicacy of the platinum wire, two pieces of which are used as a precaution in the event of one breaking: by means of the plug, the priming wires will be kept firmly in their position, and not be liable to move, which might cause a fracture in the fine wire connecting their ends: the end of the plug should have a circular hole left in it, on each side of which the flattened ends of the priming wires will lie, and being filled with fine powder in contact with the platinum wire, the ignition of the latter and of the bursting charges will be insured. The canvass bag containing it will be about 7 inches long, occupying the remaining length of the lead tube, and the vacant spaces round the sides and bottom should then be filled with the composition, and circular layers of canvass, well coated and payed over with the same, passed over the collar to cover the joint between it and the surface of the cask, and carried up a few inches on the priming wires above the collar. The ends of these wires should project about a foot beyond the top of the tube for connecting with the conducting wires, carefully insulated with tape, yarn, and composition, as above described. In order to relieve the junction of the priming and conducting wires from all strain, they should, when connected, be turned down upon the surface of the cask, and fixed there by a lashing of rope-yarn, passed round it: in working in a tide-way, or in a heavy sea, the strain would sometimes be considerable, and might be sufficient to cause the separation or derangement of the wires, unless this precaution were adopted. It may here be stated, that by having a bursting tube, the risk of the whole of the powder being spoiled in the event of the cask leaking, is obviated; for as the water, if it penetrated at all, would most probably find its way through at the joint which must necessarily be left round the collar and tube, and for securing which the greatest precautions should be taken, the powder contained in the small charge only would, in such a case, be damaged; the main body of powder still remaining dry and fit for use: the cask would therefore, in the event of a failure from this cause, have to be drawn up again, and a fresh bursting charge inserted.

In lowering a cask containing a charge of the larger size (650 ℔s.) to be fired against a wreck, a small tacle must first be used to raise it from the deck of the vessel in which the operations are being carried on: after it is in the water, it will be so well supported as only to require a line passed round a bollard, and attached to the slings to lower away upon gently: to the end of this line a buoy should be attached, to be thrown into the water for marking the position of the charge, so that on heaving the vessel or vessels out of the way, they may be placed at a proper distance: previous to the explosion, in working at a depth of 13 fathoms, a horizontal distance of 80 to 100 feet will be sufficient for safety in firing the larger charges, and about one-half that distance in firing the medium ones, while for charges not exceeding 50 or 60 ℔s., the vessels need not be moved away at all, but may remain immediately over them: it should be remembered, however, that the effects will be much greater when working at less depths, and the distances should be increased accordingly. The 72-gallon puncheon will, when filled with powder, require a weight of 4 or 5 cwt. to sink it, which may be conveniently given by attaching canvass bags filled with ballast, weighing about 1 cwt. each.

The description given for the preparation of bursting charges for casks will hold good for any description or size of charge, the rule being that the bursting charge should be equal in length to half the diameter of the vessel containing the powder; and the size of the collars, plugs, and canvass bags, will therefore be varied according to that of the main charge. Where the diameter of the plug becomes small, as in the case of bursting charges for tin cases, its end should be cut obliquely, so as to offer a

greater surface for receiving the flattened ends of the priming wires, and to insure a length of 1 inch of platinum wire, which should be its minimum length. For the tin cans, tubes of the same metal should be used for the bursting charges, soldered into the cans, at about the centre of their height. It may be remarked, that in working at such depths as 12 or 13 fathoms, the depth or height of water above the charge becomes a very efficient tamping, and a considerable effect will be produced where charges are merely laid on the surface at the bottom, for the purpose of forming a hole or crater below them, which would be frequently required where the timber or other material to be removed is buried in a mass of mud or shingle, which there is no other means of dispersing.

ON FIRING A NUMBER OF CHARGES SIMULTANEOUSLY.

This operation will be found of great use on land, as well as in working under water, and more particularly in blasting rock in quarrying, where it is frequently an object to throw down a long face of stone, and where a much greater effect may be produced by the judicious disposition of several small charges in line with each other, than if the whole of the powder were concentrated in one mass.

The simplest and most economical mode of firing several small charges or blasts on land, will be to have a main conductor consisting of the double insulated wire laid parallel to the blast-holes, but several feet in rear of the face intended to be thrown down, so that the wires may not be injured by the fragments falling after the explosion: to this main conductor will be attached at the several intervals * branch wires leading to the charges, its end being used for connecting with the extreme charge: the connections should be very carefully formed by opening the main wires at each point, and attaching the ends of the branch wires either by means of bell wire or binding screws, (the latter mode will be most expeditious,) and taking care that the wires are well cleaned and brightened at the several points of connection.

At short intervals of 10 or 12 feet, and with branches, which for small blasts need not exceed 20 feet in length, a battery of moderate power would be sufficient for firing eight or ten charges simultaneously; but it will be prudent in the first instance to fire a set of small cartridges † in the same positions as those of the intended charges, to ascertain the requisite strength of battery, which may be increased to any sufficient amount by combining two or three together: it is believed, however, that when the length of the main conductor does not exceed 400 feet, and of the branches 20 or 30 feet, two batteries of ten sets of plates each will be sufficient ‡ for a number of charges not exceeding ten or twelve, which is probably as many as could ever be required to be fired at the same time. By this mode of arrangement, the electric fluid will travel through each charge or piece of fine wire in succession, but the velocity with which electricity travels being too great to make such exceedingly

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* This was accomplished with remarkable simplicity and elegance by Capt. Larcom, R. E., in his Phœnix Park operations (December, 1843), by leading the positive wire from each charge to a mercury cup, and the negative wire to another mercury cup: into these cups the opened points of the double wire were plunged, and its other ends were connected with the battery. Thus the above-mentioned advantage was afforded of saving the main wire if any accident had happened to any of the mine wires,—as that one alone would merely have been thrown out of the mercury cup.—*Vide* Corps Papers, vol. ix. 'Phœnix Park Experiments.'—*Ed.*

† As done by Capt. Larcom, in his operations in Phœnix Park, 1843.—*Ed.*

‡ It admits of doubt as to how far this battery would be strong enough for the work described: according to some of the Phœnix Park experiments it would not. For the relations of lengths and diameters of conducting and platinum wires to the strength of the battery, *vide* Corps Papers, vol. ix.—*Ed.*

minute intervals of time perceptible, the charges may all be said to be fired at the same instant. Several interesting experiments have been tried on this subject, which prove that each secondary wire becomes ignited, as it were, at the same moment of time, and that no part of the effect is dependent upon their being consecutively broken, as has been supposed; also that in the case of the *non-ignition* of *one* of the secondary wires (which might happen if the powder in one of the charges were accidentally damp), yet all the others would be ignited and their charges fired as usual. Again, if improper metallic contact of the copper wires exists *any where*, either in the conductor or branches, the electric fluid would be stopped from passing through *any* of the charges, but would return to the battery from the point of improper contact without any effect: hence the greatest care will be required in connecting to keep all main wires clear of each other.

The above description applies chiefly to cases of common blasting, where the length of the branches and their distances apart on the main wire would be small; but in operations on a larger scale, where it may be necessary from local circumstances to have a great length of wire communicating with each charge, it would be imprudent to attempt firing several charges simultaneously by a single combination of batteries. A safer plan will be to have a battery for every two charges, or in some cases it might even be better to have one for every charge; the circuit being completed either by hand or mechanically by the mercurial igniter already noticed. In the operations at the Round Down Cliff, Dover, (which have been already described in the sixth volume of the Professional Memoirs,) each charge had a separate battery and wire of 1000 feet in length, and the three mines were fired quite simultaneously by the same number of operators, one at each battery, who completed the circuit by word of command.

At Spithead, in the summer of 1843, we fired three large charges together, over the wreck of the *Royal George*, by means of a main wire and branches, (the latter 100 feet in length and 20 feet apart,) the end of the main wire being used for the extreme charge, and the battery, consisting of forty plates of iron and twenty of zinc, being applied at the opposite end. Here the charges were fired, though the reports were successive rather than simultaneous. But an attempt made some time after to fire six charges together in the same manner by a combination of three powerful batteries, partly failed; four only out of the six exploding, and those not simultaneously, but with a perceptible interval between each report. These facts, together with others deduced from numerous experiments afterwards tried with small water-proof bursting charges sunk to the bottom, proved that for simultaneous firing under water it would be preferable to have a number of smaller batteries, with a separate wire for each charge, rather than an equal strength of battery combined in one with a single focus of ignition,—an additional reason for which would be the difficulty of managing so many wires in a subaqueous operation, when attached to a main conductor.

In forming the simultaneous contact of a number of separate wires, the mercurial igniter will be found very convenient, which should consist of two parts: a stand or stool, about 18 inches high, with a front frame containing as many cups or receptacles for mercury as there are wires, and an arm or cross piece hinged to the back of the stand, with a corresponding number of short pieces of stout copper wire let into it, and suspended over the frame in such a manner that on being let down each piece of wire will enter a cup of mercury below it; one pole of each battery, and the end of one side of each conducting wire, being then connected to each other either by screws or bell wire. The second pole of the battery may be let into a mercury cup, and fixed there, while the other end of the conductor to which it is to be

connected will be attached to the piece of copper in the arm immediately above it: the same arrangement being made for all the wires and batteries, it will only remain to let the arm fall down upon the cups, when, the circuit being completed at the same instant by the upper wires entering the mercury, the whole of the charges will be simultaneously fired.

Before attaching bursting charges to a conductor, it will be essential to prove that the circuit is complete, and the platinum wire perfect; for being extremely delicate, this secondary wire is occasionally liable to be broken in spite of all precaution. The readiest mode of doing so will be by means of the instrument called the 'galvanometer,' the principle of which is founded on the well known influence of voltaic electricity on the magnetic needle: a full description of its construction is given in the account of the operations at the Round Down Cliff, Dover, in the sixth volume of the Professional Memoirs: the voltaic pair there used consisted simply of a small plate of zinc within a copper case; but this may be improved by making the voltaic pair a small single cell of a Daniell's battery, by which the action will be much longer kept up, and the zinc will not so soon perish: the action of the needle will be more visible if the coil of wire surrounds it vertically rather than horizontally. In the former case it will be deflected, and will place itself at right angles to the coil: in the latter case it will move vertically, and the northern end will be elevated or depressed according to the order in which the ends of the rectangle are attached to the voltaic plates.

Another mode of proving the completeness of a circuit by means of the 'water-test apparatus,' or the power of the electric circuit to decompose water, may also be used, but it will require a more powerful battery, and not be so quickly performed as by the 'galvanometer,' by which 100 cartridges may be proved in less than half an hour. In carrying on operations of this kind, it will also be occasionally useful and interesting to try the relative power of different kinds of batteries and lengths of wire, for which purpose the voltameter or decomposition apparatus may be employed, which is constructed so as to measure off the quantity of gas emitted when water is decomposed, and thus to indicate the amount of electricity passing in a circuit.

There are various forms of voltameter, but the one most commonly employed, and which would give the most accurate results, is that in which the water (slightly acidulated) is contained in a glass vessel of moderate size, closed at the top, into or near the bottom of which are fixed two pieces of platinum wire about $\frac{1}{4}$ of an inch apart. A glass tube, whose interior diameter may be $\frac{1}{2}$ an inch, graduated to cubic inches and parts, is supported over these poles, entering the water to some depth. The tube being also filled by inverting the vessel, the mixed gases will be collected in it on connecting the ends of the wires or poles of the battery with those of the voltameter, and by keeping a record of the quantities of gas delivered per minute, or per half minute, using different kinds of batteries and lengths of conducting wire, we may arrive very nearly at the relative powers of the former, and the proportional resistances offered by the latter.

Another form of voltameter is that in which two tubes are used over each pole, to collect the gases which may be evolved, separately or singly.

REFERENCES.

Zinc and Copper Battery.

Plate I. Ordinary battery.

Fig. 1. Diagram of the Galvanic Principle.

Fig. 2. Isometrical view of a zinc plate and copper case, with a portion of the copper removed.

Fig. 3. Three sets of plates connected.

Fig. 4. Portion of a copper case and zinc plate on an enlarged scale, shewing the connecting band and screw.

Fig. 5. Isometrical view of a battery of ten sets of plates connected.

Fig. 6. Trough containing the acidulated solution, in which the battery is immersed. *h*. Orifice for discharging the solution.

Fig. 7. Section of three sets of plates, shewing a method of connection by leaving a tongue or flap projecting on one side of the copper case, to be turned up against the adjoining zinc plate, and connected with it.

Fig. 8. Plan of ditto. *c*, *c*, *c*, shew the projecting flaps.

Fig. 9. Clamp-screw to be used for this method of connection.

Figs. 2, 3, 5, and 6, are on a scale		$\frac{1}{12}$	full size.
Figs. 4 and 9	"	$\frac{1}{4}$	do.
Figs. 7 and 8	"	$\frac{1}{8}$	do.

Plate II. Cast iron and zinc battery of 10 cells.

Fig. 1. Plan of trough.

Fig. 2. Isometrical view of the battery raised above its trough.

Figs. 1 and 2 are on a scale $\frac{1}{8}$ full size.

Plate III.

Fig. 1. Isometrical view of battery of alternate plates of cast iron and zinc, the trough without partitions.

The battery is shewn supported above the trough, by the wood pins (p, p), which are to be removed before lowering it. The plates are supported by a piece of board at the bottom, let into the ends of the frame, similar to the pieces (s) at the sides: the bottom piece is not seen in this view.

Fig. 2. Section shewing nine of the plates on an enlarged scale, with the method of connection: the iron plates are shaded and marked i^1, i^2, i^3, &c.; the zinc plates are marked z^1, z^2, z^3, &c.

Fig. 4. Transverse section through A, fig. 1, Electricity Plate V.

c, *c*. Circular orifices, $\frac{3}{4}$ inch diameter, at the bottom of each partition, at contrary ends, for passing the fluid through the cells.

Fig. 5. Transverse section through C or D, fig. 2, Electricity Plate V.

Plate IV.

Fig. 1. Section through a 5-gallon tin can, holding about 50 ℔s. of powder, shewing it prepared as a charge for submarine operations. *l*. Loading-hole. *b*. Bursting charge: the priming wires are shewn lashed to the handle and surface of can, so as to relieve the platinum wire within the bursting charge from all strain.

Fig. 2. Section through the bursting charge of fig. 1, shewing the collar (C), plug (P), and canvass bag containing the powder.

Figs. 3 and 4. Collar and plug for bursting charge, fig. 2, shewing the neck of plug for tying round the canvass bag.

Fig. 5. Plan or end view of plug, shewing the ends of the priming wires turned down against the surface, and the platinum wire lying across them: the spherical hole is left for being filled with fine powder in contact with the platinum wire.

Fig. 6. Pointed charge to be used in clearing away mud or soft ground: when forced down to about $\frac{3}{4}$ths of its depth, the effect of the explosion will be very great.

Fig. 7. A mode of lashing two cans together to form one large charge, if required, with the method of connecting the two inside priming wires of each bursting charge, so that the platinum wires of both charges may be included in the same voltaic circuit, and fired together. This arrangement has answered well on several occasions.

Fig. 8. Section of a blast-hole in rock prepared for firing by the voltaic battery, as recommended by General Pasley: the tamping is formed by a cone of hard wood, to the bottom of which is attached the canvass bag holding the powder, and the hole filled up with small broken stone.

Figs. 9, 10, and 11. Section, plan, and elevation of a bursting charge or cartridge, to be used for voltaic operations on land, where the quantity of powder to be fired exceeds 200 or 300 lbs.

Fig. 12. Small cartridge for experiments, and which may also be used for firing small mines: the cases of these may either be formed of tin or pasteboard; if the former, care must be taken to keep the wires from touching it.

Figs. 1, 6, and 7,	are on a scale	$\frac{1}{12}$	full size.
Figs. 2 to 4, and 8 to 12	„	$\frac{1}{4}$	do.
Fig. 5 . . .	is on a scale	$\frac{1}{2}$	do.

Plate V.

Fig. 1. The copper and zinc plates being immersed in water, and their surfaces connected by the wire *w*, *w*, it will be found, on placing a galvanometer (G) within the circuit, that a voltaic current of considerable intensity is passing through the water from the zinc to the copper, and returning by the wire. The distance between the copper and zinc plates may be considerable,—a mile or more.

Fig. 2. Shewing the method of firing submarine charges by a single wire, making the sea or other depth of water complete the circuit.

The ends of wires A and B are led to a voltaic battery.

Wire A goes to the negative or zinc pole.

Wire B goes to the positive or iron (or copper) pole.

p, *p′*. Priming wires of bursting charge.

C. Point of contact of priming wire *p′*, with surface of charge, attached by a lashing of rope-yarn.

The greatest length or depth of water-conductor known to have been used hitherto for firing charges in submarine operations does not exceed 100 feet, but it is presumed that the same principle may be extended to much greater depths.

Plate VI.

Fig. 1. Enlarged section of loading-hole.

P, P. Wood plugs. C. Composition.

Fig. 2. Longitudinal section through a 72-gallon puncheon, prepared for a submarine explosion by the voltaic battery, shewing the double thickness of head with the loading-hole (*l*) through it, and the lead tube (*t*) for the bursting charge. Size of charge about 720 lbs.

Fig. 3. End view of head, shewing the cleat and plug closing loading-hole, the staves (*s*) lashed round the surface to guard it from friction, and ballast bags to weight the charge in lowering it to the bottom.

Fig. 4. Side view of cask prepared for lowering, shewing the slings, staves, &c.: the priming wires are relieved from strain by being secured by the lashing round the cask at X.

Fig. 5. Section through bursting tube and charge on an enlarged scale, shewing the collar, plug, canvass bag containing the powder, &c. The vacant spaces are filled with composition. The tube may be made of lead pipe, with a bottom soldered on and the top beaten out to form flange for screwing to the cask.

Fig. 6. Section through collar on an enlarged scale: the circular orifice is left to pass the priming wires through.

Fig. 7, side view, and fig. 8, plan of bottom of plug, shewing the grooves for the wires, with the ends flattened and connected by the two pieces of platinum wire.

Fig. 9 shews an arrangement for firing several small charges or blasts on land simultaneously, by a powerful battery applied at one end of the main wire.

Figs. 1 and 5 are on a scale		$\frac{1}{8}$ full size.
Figs. 2, 3, and 4	,,	$\frac{1}{2}$ in. = 1 foot.
Figs. 6, 7, and 8	,,	$\frac{1}{4}$ full size.

Plate VII.

Fig. 1. Isometrical view of a mercurial apparatus or igniter for forming the simultaneous ignition of several mines.

The upright (A) is hinged to the inside of the frame, and on being unhooked falls down upon the front piece containing the six cups (C) filled with mercury: the pieces of wire, let through the arm (B), numbered from 1 to 6, enter the similarly numbered cups at the same instant, the connections being completed by the wires 1^1, 2^2, 3^3, &c., which enter the bottom of the cups, and are turned up against the front part of the frame. The two extreme batteries, 1 and 6, are here only shewn connected with their conducting wires and the apparatus: the intermediate batteries would be conducted in the same manner, but are not shewn, to avoid confusion.

Fig. 2. Section through front of frame, and mercury cup on an enlarged scale, shewing the arm down upon the frame, with the connection complete.

Plate VIII. Professor Daniell's cylinder battery.

Fig. 1. Isometrical view of cylinder battery connected.

Fig. 2. Battery in plan.

Fig. 3. Box in plan.

Fig. 4. Section through A, B, C, D, fig. 2.

c, c. Copper cylinder.

s, s. Sulphuric acid, water, and sulphate of copper.

z, z. Zinc rods, within ox-gullets, containing dilute sulphuric acid only.

Plate IX.

Figs. 1 and 2. Galvanometer.

C. Single cell of a Daniell's battery. Copper cylinder $2\frac{3}{4}$ inches diameter, and $2\frac{1}{2}$ inches high.

Z. Zinc rod, $\frac{1}{2}$ inch diameter.

D. Rectangular coil of insulated wire, $\frac{1}{16}$ inch diameter, surrounding the needle in a vertical direction: one end of the wire is connected to the cylinder at X; the other end forms the positive pole of the galvanometer.

In testing the completeness of an electric circuit, the two ends of the wire forming that circuit must be brought in contact with the poles (P, P′) of the galvanometer, when the needle will be instantly deflected if the circuit is perfect.

Fig. 3. Voltameter.

A. Glass vessel closed at top, containing acidulated water.

T. Graduated glass tube entering the liquid in the vessel.
p, *p*. Platinum wires, hermetically sealed into the tube.
s. Stopper for closing the second orifice, while the vessel is inverted for filling the tube.

Fig. 1 is on a scale 1 in. = 1 foot.
Fig. 2 „ ¼ full size.
Figs. 3 and 4 are on a scale ½ full size.

'Voltaic Electricity'
ELECTRIC TELEGRAPH.—*Vide* '~~Galvanism~~.'

The Editors have to regret this untoward postponement,—and that Professor Wheatstone, who kindly offered to supply this Article, has not as yet had leisure sufficient for its completion.

ELEPHANT.*—For military purposes, and in modern warfare, it is not probable that the elephant will ever again be met with, except in connection with troops moving in India, and the neighbouring countries in which Indian armies are most likely to be employed, viz., the Punjaub, Burmah, &c. It has never been reduced to subjection and applied to useful purposes in Southern Africa, where it abounds; while its employment, whether for war or otherwise, in the northern part of that continent, appears to have gradually lessened from the period of the Punic Wars, until its use was finally discontinued about the age of the later Roman emperors.†

In general the elephant is employed only as a *beast of burthen;* it is by no means well adapted *for draught.* Its great size and bulk render large and cumbrous waggons or carriages necessary, as well from those causes, as for the stowage and conveyance of a load proportionate to its strength; and this, though not very objectionable in a settled and level country, provided with good roads,‡ is fatal to its utility in such a manner with an army in the field. Nature, too, appears to have

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* By Captain Hawkins, R. E., embodying Notices from Lieut.-Colonel Colvin, H. E. I. C. Engineers.

† On referring this question to Lieut.-Colonel Hamilton Smith, that learned writer kindly sent several memoranda of much interest from the early historical records of the military use of the elephant: the following abridged extracts from his letter refer to that animal as formerly used in Northern Africa.

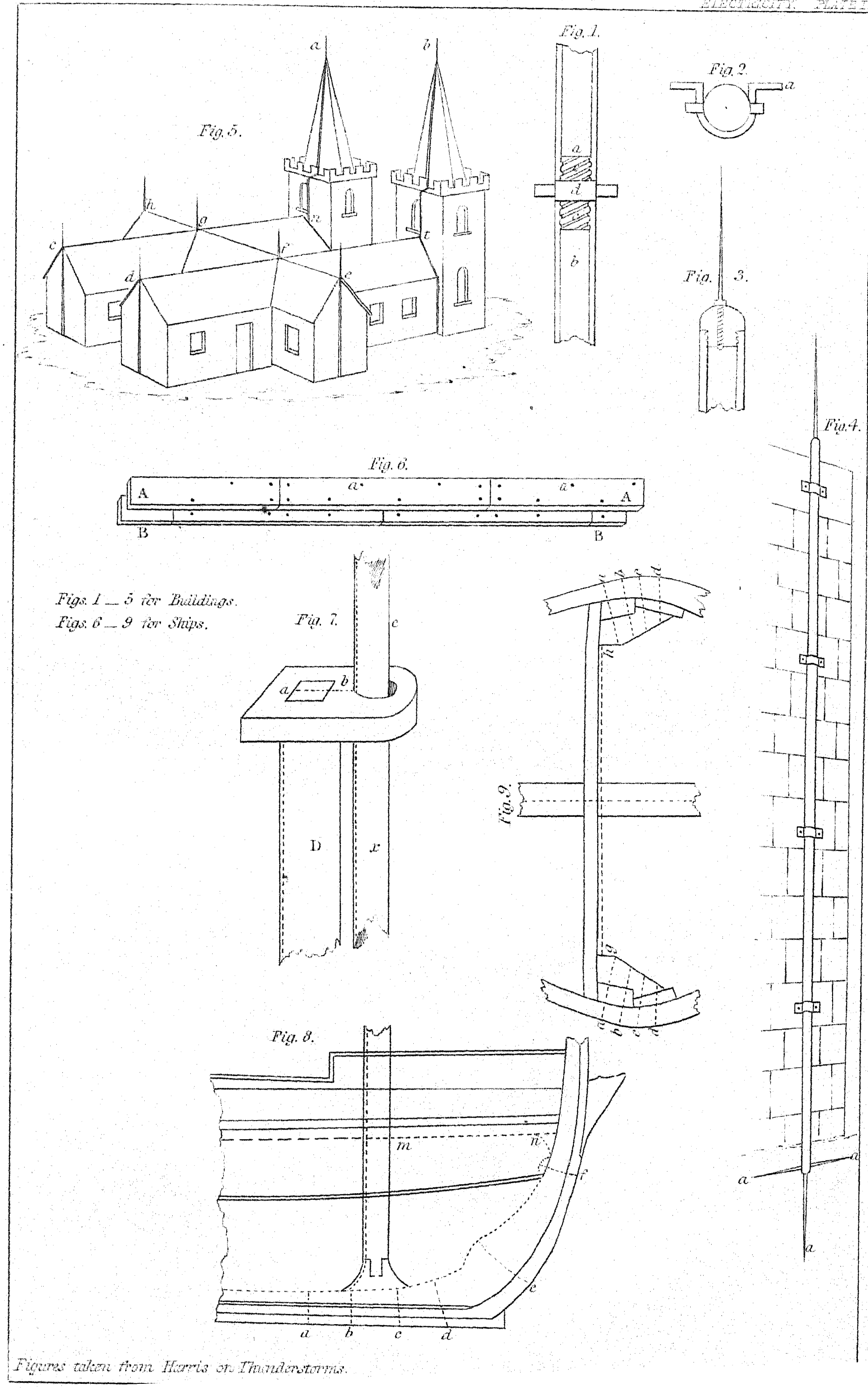
"The elephant was used by Ptolemy Philadelphus, who had 300 or 400 in his service.

"The African elephant appears never to have been so well trained as the Asiatic;—when used by Ptolemy Evergetes, they fled as soon as they became aware of the presence of those of Asia. In Pliny, (Hist. Nat. lib. viii. cap. 9,) we find, 'Indicum Afri pavent, nec contueri audent; nam et major Indicis magnitudo est.'

"The Carthaginians do not appear to have used them before the first Punic War in Sicily; and Scipio's defeat was not improbably hastened by the mohouts of his 64 elephants having been bribed, as these men were of that venal and treacherous race,—the Numidians.

"The Romans made a resolution never to make peace with any nation that had elephants."

‡ Elephants are not much used in Ceylon; but in that island they are applied as much to draught as otherwise, subject to the local advantages alluded to in the text. It is doubtful to the writer of this Article if the quantity of work usually performed by them is proportionate to their strength and cost. For application of their weight and strength in heavy floods, *vide* Corps Papers, vol. iii. p. 156.



Figures taken from Harris on Thunderstorms.

ELECTROTYPE, PL. 1.

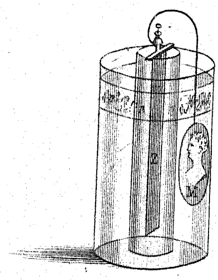
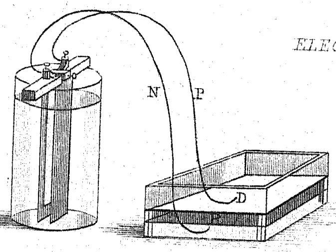


Fig. 1.



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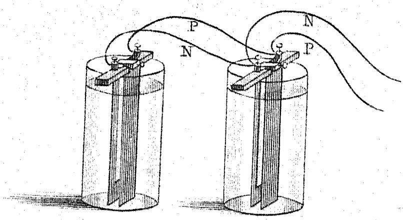


Fig. 3.

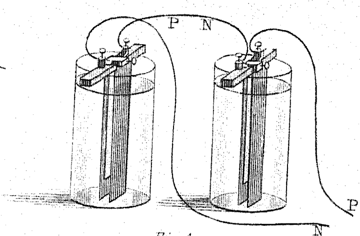


Fig. 4.

Fig. 5.

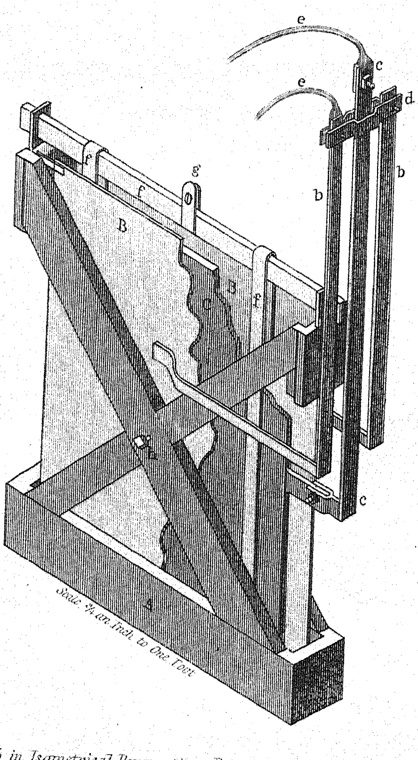
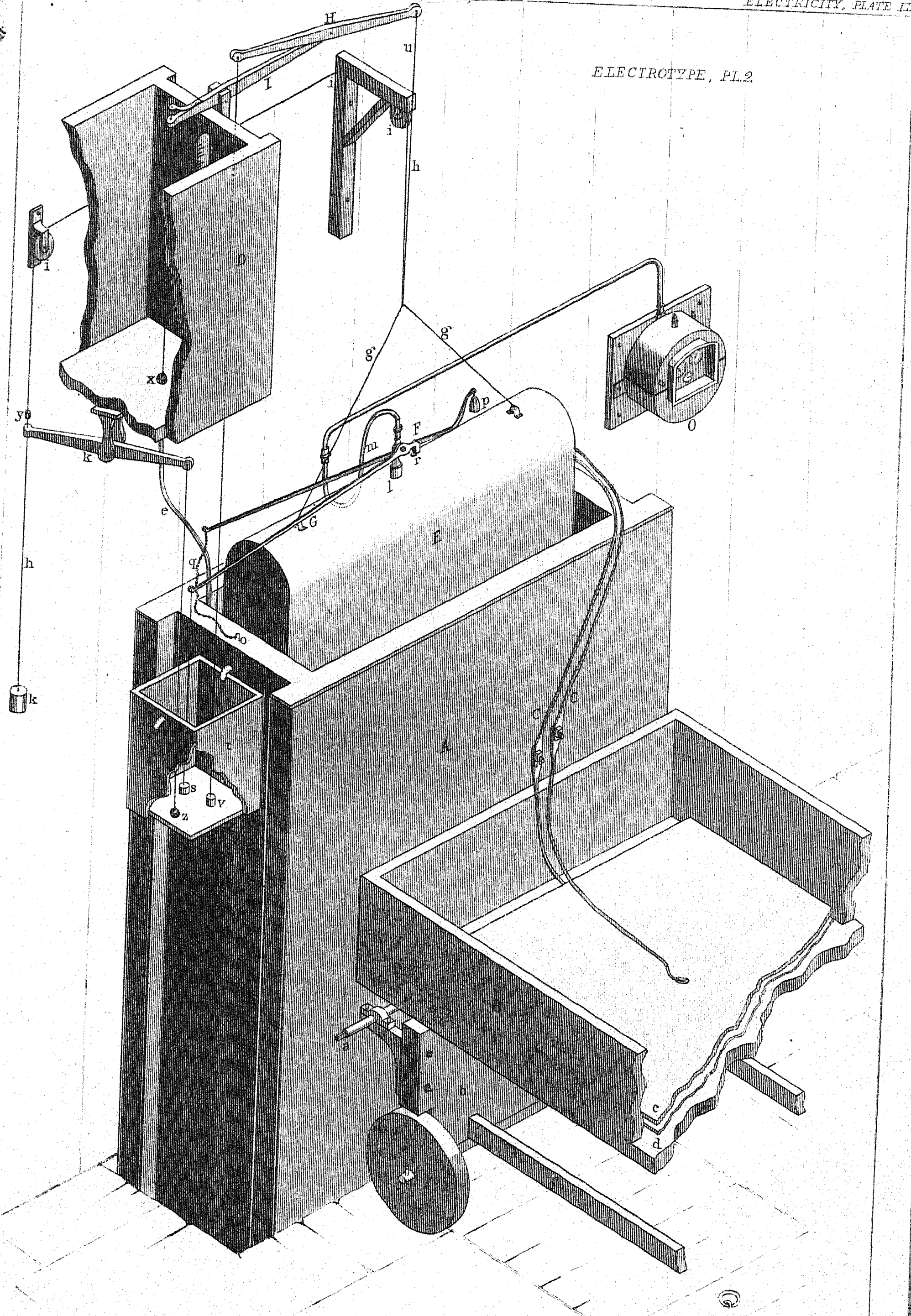


Fig 5 in Isometrical Perspective. Pair of Battery Pl

ELECTROTYPE, PL. 2



Scale. 3/4 of an Inch to One Foot

ONE OF THE BATTERY AP...

EXPLOSION OF MINES PL.1.

Details of a Voltaic Zinc & Copper Battery of 10 Cells.

Fig.1.

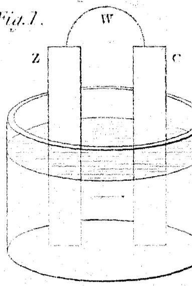


Fig.2.

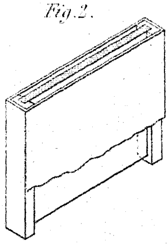


Fig.3.

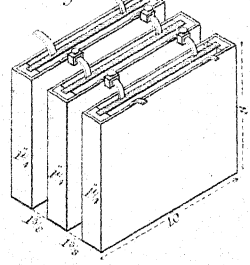
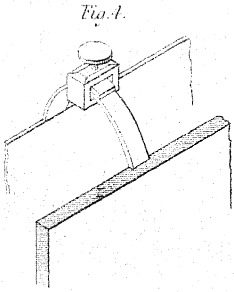


Fig.4.



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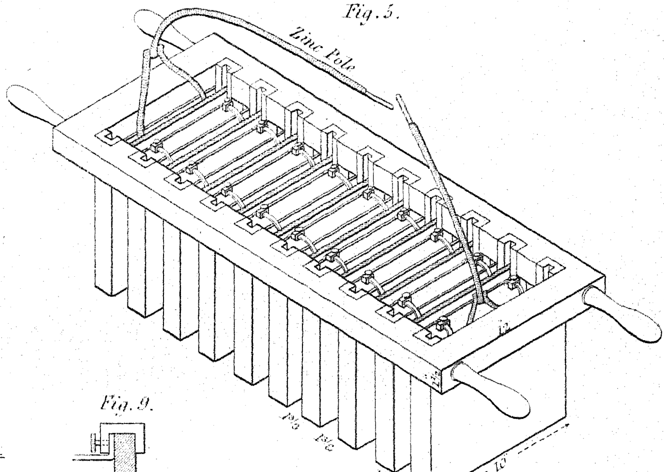


Fig.7.

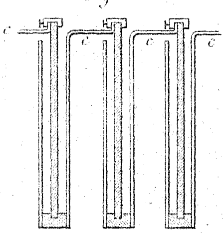


Fig.9.

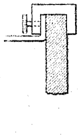


Fig.8.

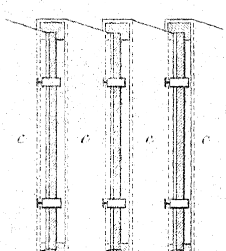
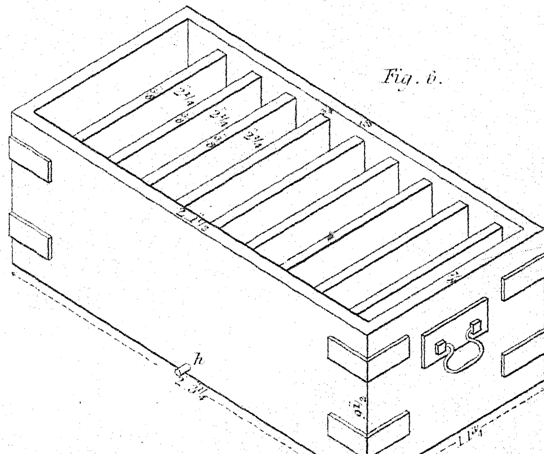


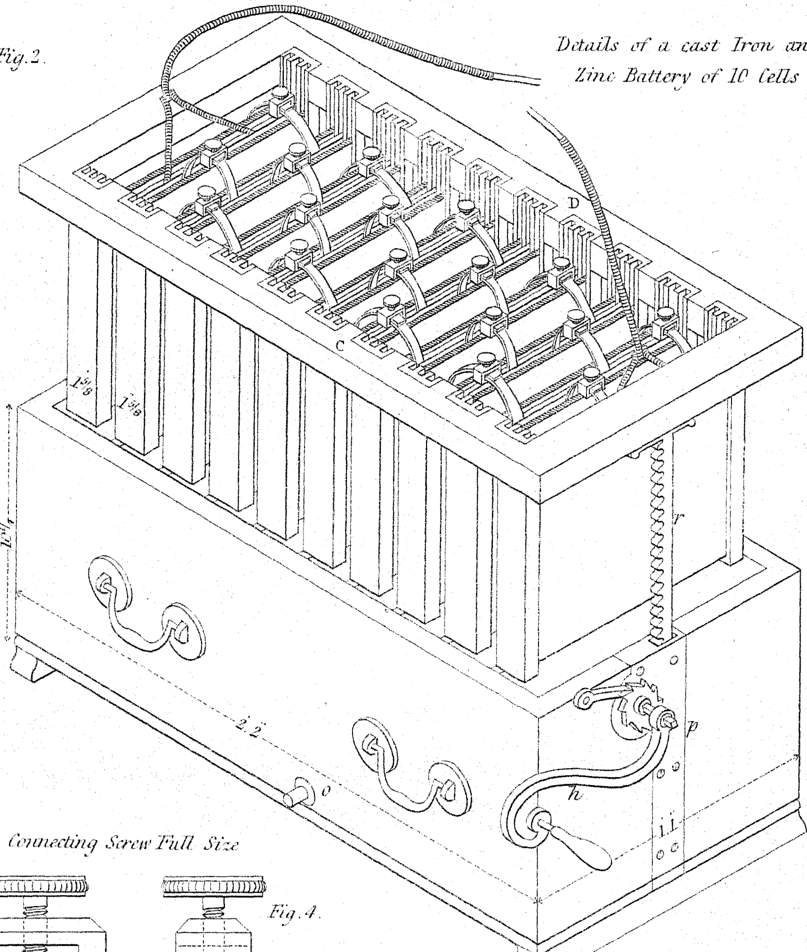
Fig.6.



EXPLOSION OF MINES, PL. 2.

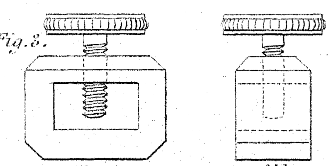
Fig. 2.

Details of a cast Iron and Zinc Battery of 10 Cells



Connecting Screw Full Size

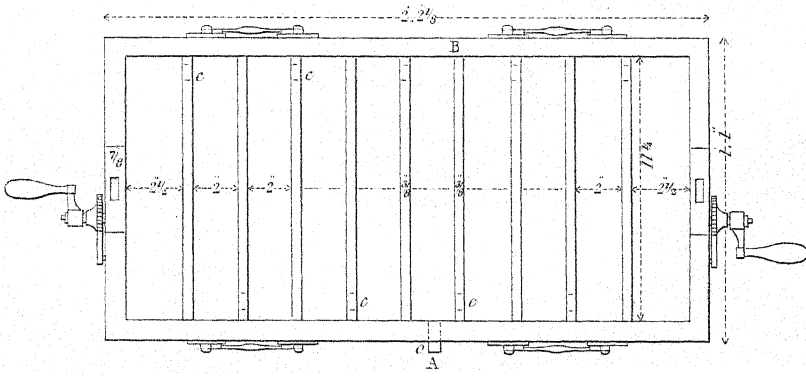
Fig. 3. *Fig. 4.*



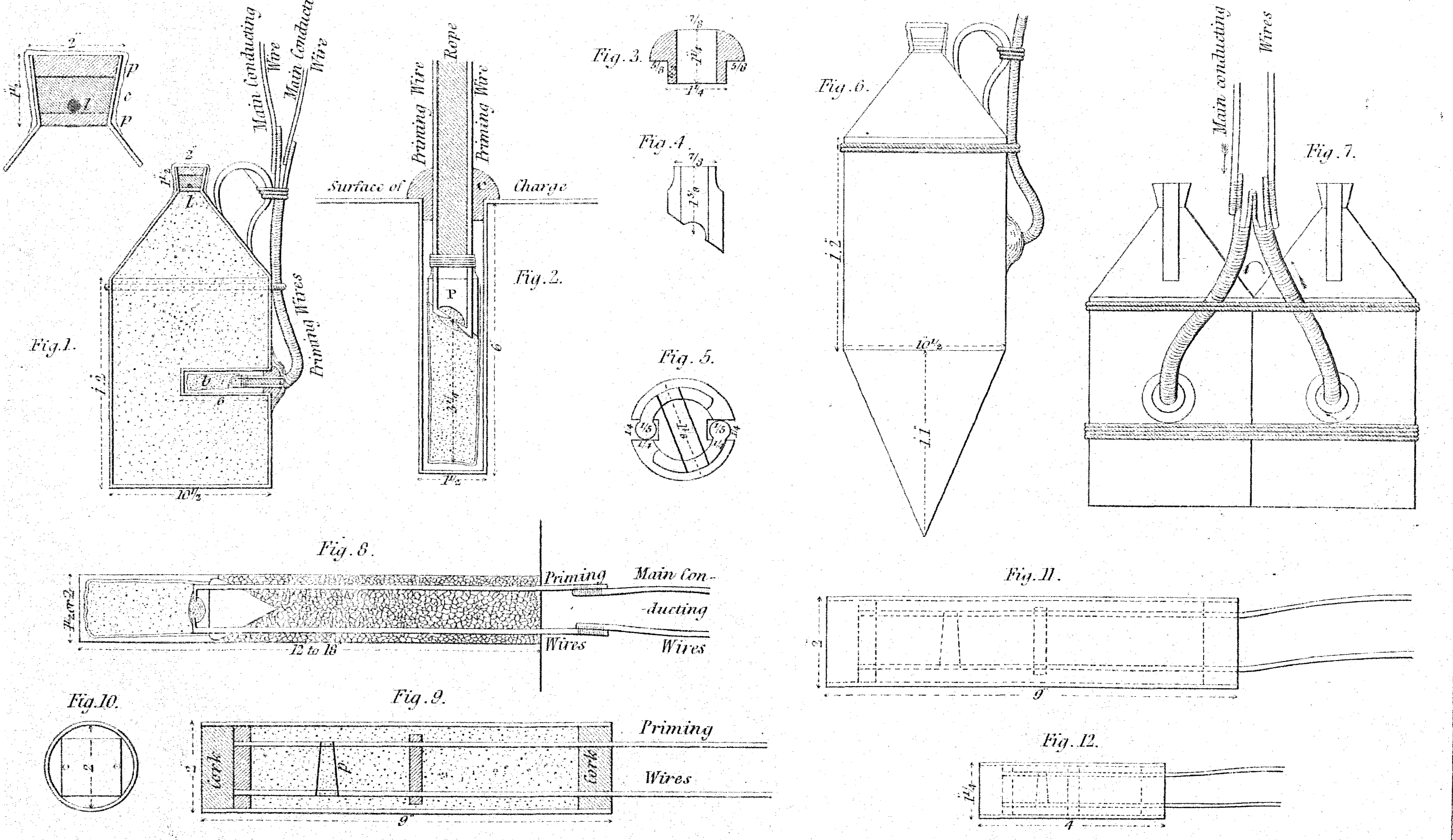
Front *Side*

Elevation

Fig. 1.



EXPLOSION OF MINES PL. 4



EXPLOSION OF MINES PL. 5.

Sketch to illustrate the principle of firing Submarine Charges by a Single Wire.

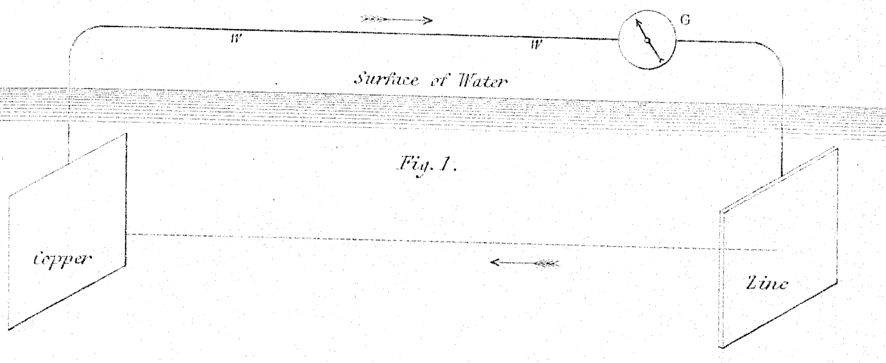


Fig. 1.

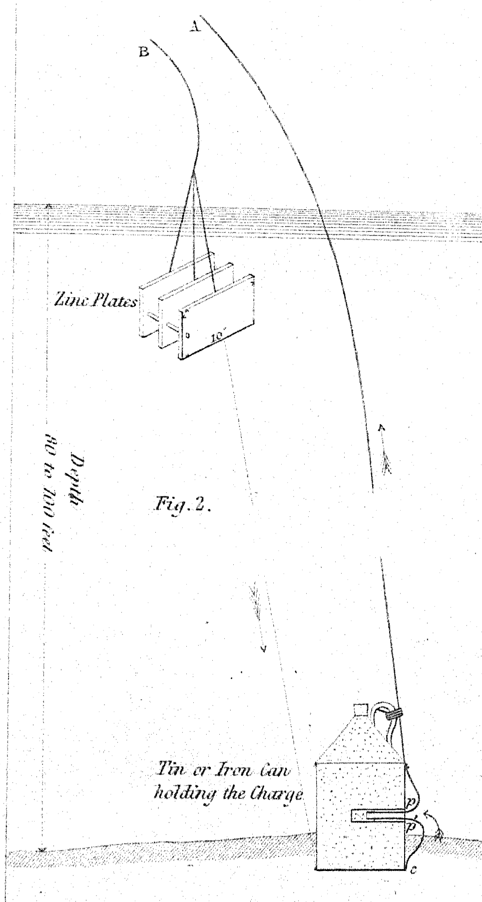


Fig. 2.

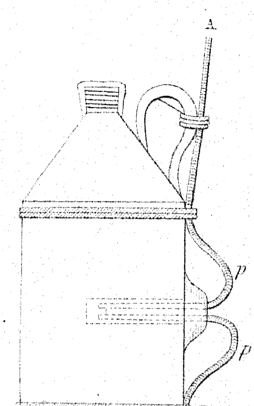
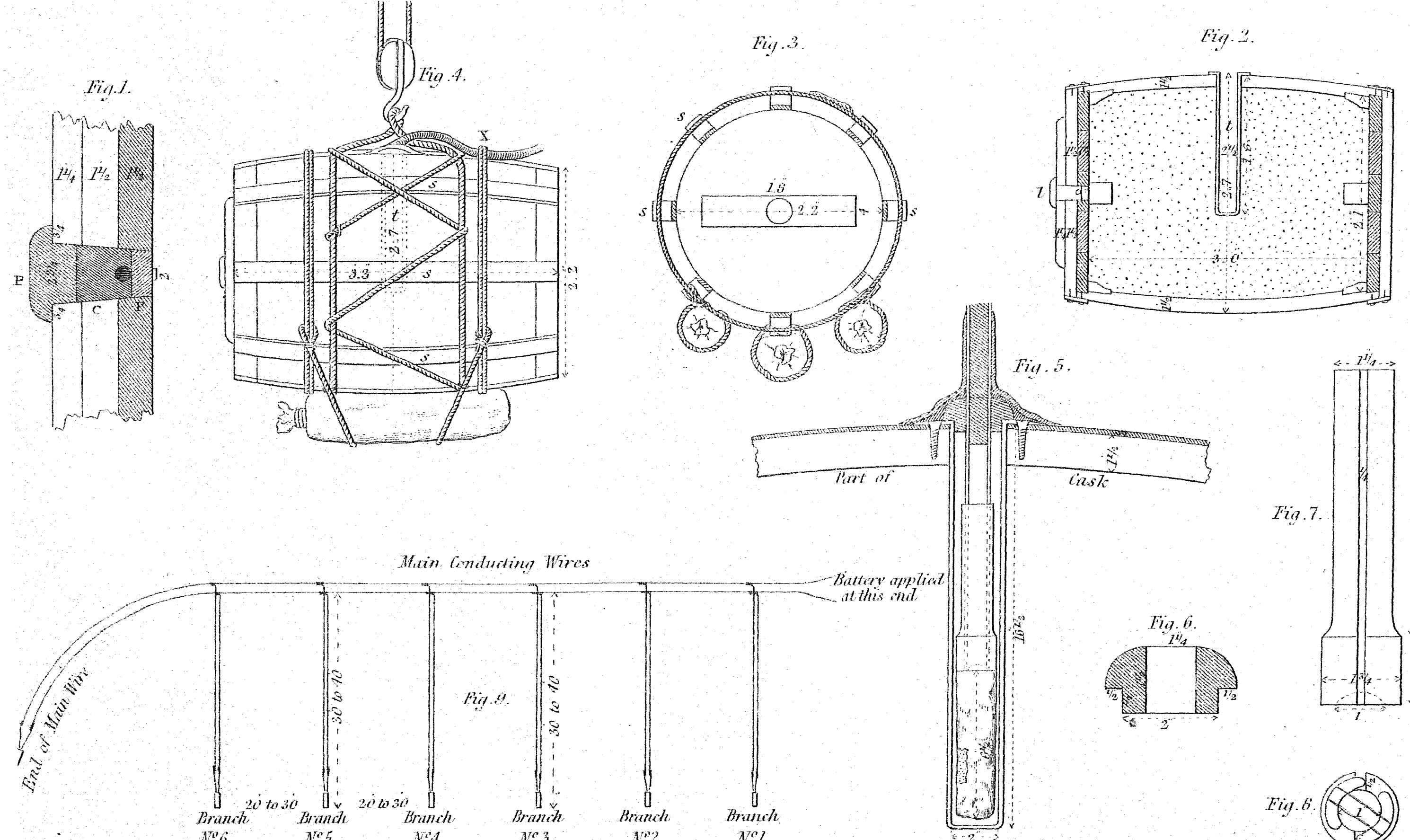


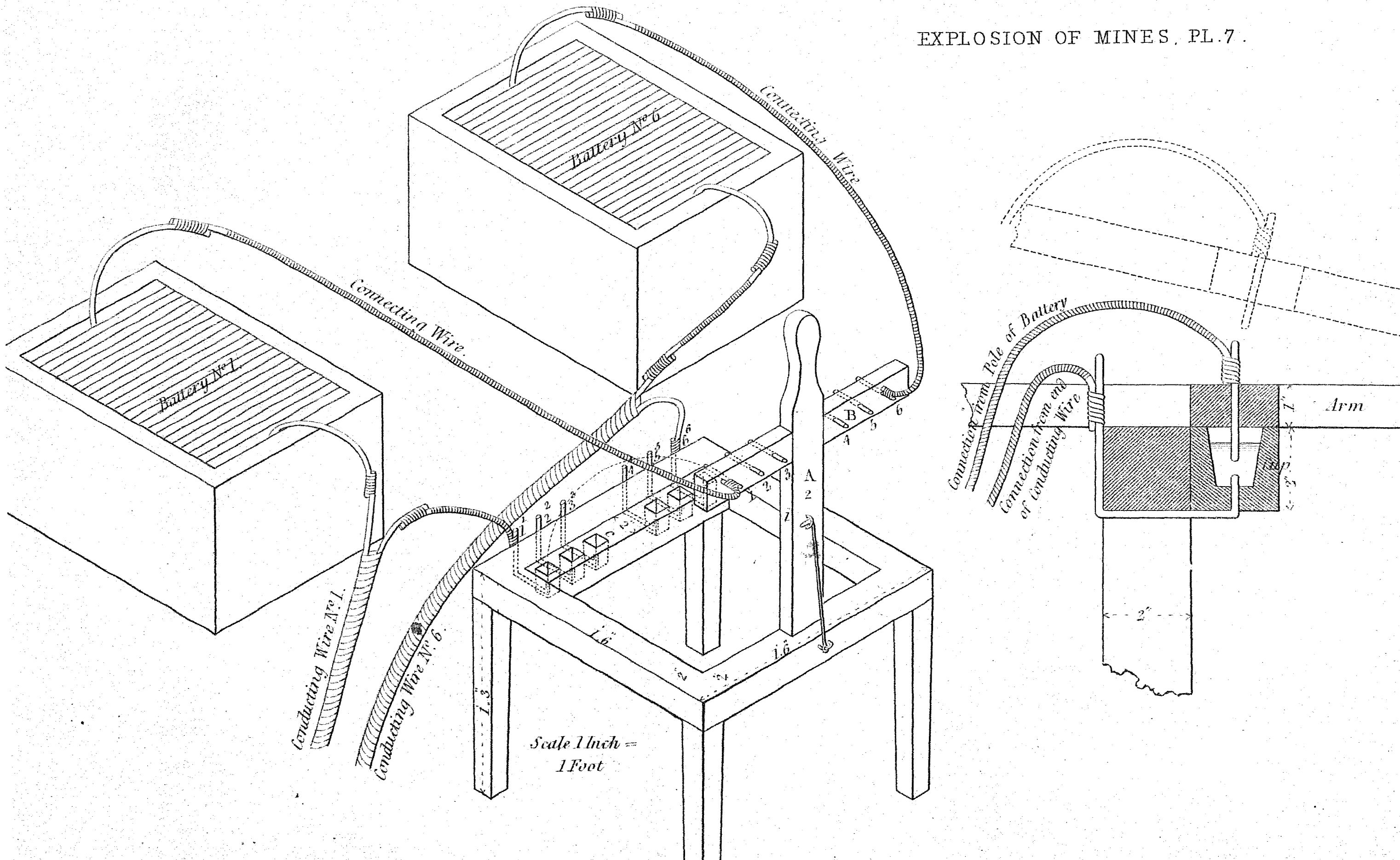
Fig. 3.

Elevation of a 5 lb. Charge prepared for firing by a single Wire for a submarine operation.
Scale 1/12 full size.

EXPLOSION OF MINES PL. 6.



EXPLOSION OF MINES, PL. 7.



EXPLOSION OF MINES. PL. 9.

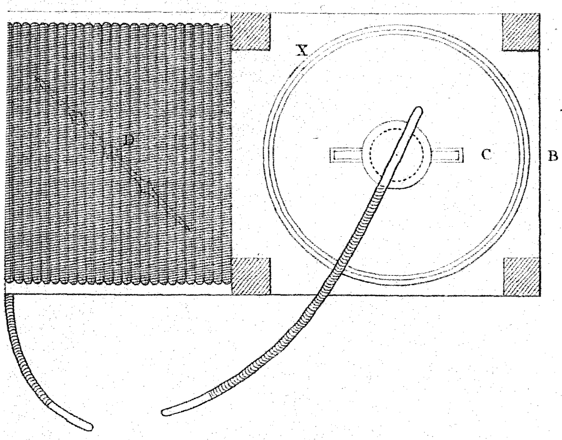


Fig. 1.

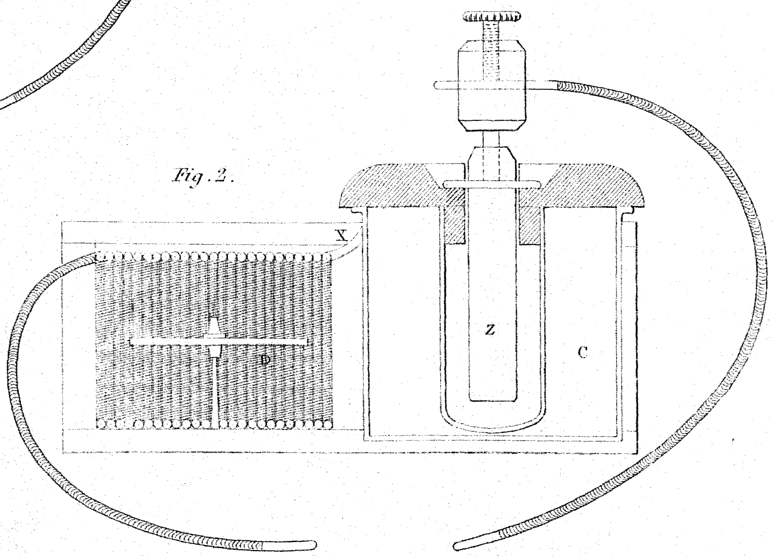


Fig. 2.

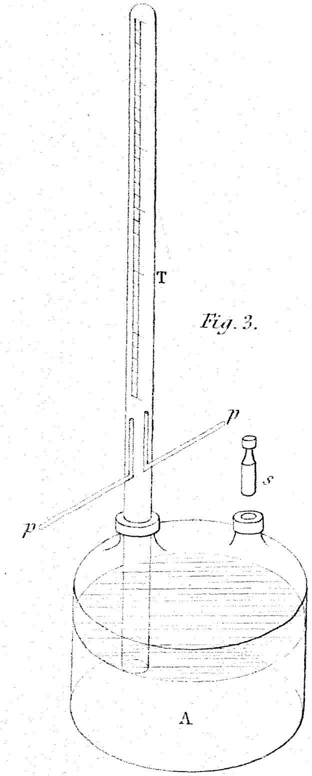


Fig. 3.

formed the elephant rather for bearing than for dragging weights. Its shoulder is not suitable for a collar, which is the best method of applying the power of a draught animal; and the upright and bulky formation of the leg and shoulder is far better calculated to support a burthen than to allow of the due application of the animal's strength and weight in draft.*

The elephant is most usually employed for the transport of large tents and other articles of equipment, of weight beyond the power, or of size inconvenient to be carried by camels or bullocks. Its load for steady work varies from about 15 to 20 cwt., exclusive of the pad or pack-saddle. With this it travels at the rate of 3 miles an hour, from 16 to 20 miles per diem; but it can perform and bear longer marches for some time without injury. On an emergency, a *riding* elephant can travel at the rate of five miles an hour, and will go about 40 miles in a day; but for a continuance, its performance will not much exceed that of the baggage elephant.

The number of elephants accompanying an army in the field will always be relatively small from their comparative scarcity; and the principal means of transport must depend on the supply of camels, bullocks, &c. Their manner of employment must be ruled entirely by circumstances, and it is difficult to enumerate their many probable uses. From their very great strength, and the *unity* of its application, it may, doubtless, be frequently found advisable to apply them to draught, particularly of artillery, notwithstanding the objections previously urged in this notice. Their power, too, would be constantly and beneficially required for *assisting* in the transport of artillery, heavy carriages, &c., independent of the actual traction. And in this manner siege and heavy guns attached to the armies of Native (Indian) powers are generally accompanied by elephants on the line of march, for the purpose of assisting their progress.

The camel 'knocks up' very quickly on stony ground, and in wet weather on clayey soils. To this the elephant is less liable; and valuable at all times, in such cases it becomes doubly so: as also in rough or mountainous districts, for which the camel is ill-adapted by nature, and in which the smaller animals suffer much from being overloaded or overtasked. In such countries the elephant has also been advantageously used for the *carriage* of light mountain artillery (where it could not be dragged); the gun and carriage being separately secured on the pad.

The average price of baggage elephants is from £40 to £50 apiece, and of riding elephants from £80 to £120. They become fit for work at about twenty years of age, and with ordinary work and common care can be calculated upon for from twenty to thirty years, and often last for a much longer period.

The average monthly expense of an elephant is about £4, of which from 30 to 36 shillings is for the hire of attendants. Each elephant requires a 'mohout,' or driver, and two attendants to procure forage, &c.: when fodder is purchased, or green forage is not used, one attendant only is necessary in addition to the driver; but this cannot be calculated upon in moving with troops. The daily allowance of food is from 20lbs. to 30lbs. of wheat flour, baked into thick cakes, and about 1lb. of coarse sugar or molasses; about 1 cwt. of green forage, consisting of branches of the peepul, ficus Indicus, and other trees, or of grasses; or if green food is not given, of the same quantity of rice or other straw. In rice countries the same weight of rice (paddy) is usually given instead of the wheat flour. The allowance varies, as above

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* Colonel Smith also quotes from Ctesias (and Photius, as also cited by Colonel Todd, in his Rajahstan) an application of the elephant, when suitably trained and harnessed, to overturn gates and 'ramparts:' in this case they were of the largest bulk (the Asiatic elephant rarely exceeds 11 feet in height), and were called by Photius Τειχοκαταλυτης.

stated, with the size of the beast and health of the animal, and with the province in which it is employed. An occasional physic or spice (cordial) ball is necessary. Elephants are somewhat delicate in their artificial and domesticated state; they require much care and attention, as well as regular and good supplies of food. They are liable to disease, especially from neglected sores, caused by badly fitted pads.

The data for the above notice were obtained from authentic sources, and are founded principally with reference to the employment of elephants in *ordinary* travelling in India. It would appear that with large bodies of troops these useful animals must be looked upon as invaluable *auxiliary*, and not as principal means of transport, being much too costly and too scarce to be made generally available as the latter. In the native armies, the disappearance of the chief's elephant is generally the signal for that of the rest in immediate retreat.

P. S. Experiments have lately been made in applying elephants to the draught of light field batteries in India; but they have been considered totally unfitted for such service. If thus used, quite independent of other disadvantages, a single shot might cripple an elephant, and thus virtually disable the gun to which he is attached; while half the usual number of horses or bullocks might be injured without materially interfering with its efficiency in action.

In the newspaper detail of the "Army of the Sutlej" advancing to Ferozepore, an "elephant battery of iron 12-pounders" is mentioned; but this, probably, refers to the means of transport of the battery, rather than to the manner in which these pieces would be brought into action, as they must have been position guns.

EMBARKATION.—*Vide* 'DISEMBARKATION.'

EMBRASURE V. 2e Vol 2. P. 312.

ENGINEER, MILITARY.*

Under this head will be comprehended—

1. The Corps of Royal Engineers,
2. The East India Company's Corps of Engineers,
3. The Prussian Corps of Royal Engineers,
4. The Corps du Génie of France,

of which Services only authentic accounts have been obtained of their organization, composition, and duties; but as those of other countries are based upon either of the above, the want is not perhaps of importance.

SECTION I.

1. *The Corps of Royal Engineers, and Corps of Royal Sappers and Miners*, forming one establishment; the former comprising the officers, and the latter the non-commissioned officers and privates. These corps at present constitute about one-sixtieth of the British army or regular forces, exclusive of those in India.

2. *Composition.*† The actual strength of the corps in 1846 is six battalions of Officers, and 18 ‡ Companies of Sappers and Miners; besides 14 Officers seconded in

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* By Colonel Lewis, C. B., R. E.

† It is difficult to explain what produced this arrangement, in a body consisting only of Officers, and why the Battalions and Companies are organized without men: see the Composition of the Corps du Génie of the French Service.

‡ *Vide* Ordnance Estimates, 1846-47.

employment in the civil branches of Her Majesty's Government, most of whose duties correspond somewhat with the Engineers of the Ponts et Chaussées of France.

The strength of the Effective Corps consists of—

Colonel, the Master-General of the Ordnance.

Staff of the Corps,	1 Inspector-General, 1 Assistant Adjutant-General.
Corps of Royal Engineers, 290 Officers in 6 Battalions,	6 Colonels Commandant, 12 Colonels, 30 Lieutenant-Colonels, 48 First Captains, 48 Second Captains, 96 First Lieutenants, 48 Second Lieutenants.*
Corps of Royal Sappers and Miners,	1 Brigade-Major, 1 Adjutant, 1 Quarter-Master, 2 Serjeant-Majors, 4 Staff Serjeants, 15 Companies, consisting of 1462 Non-Commissioned Officers, Privates, and Buglers. 3 Survey Companies, consisting of 315 ditto ditto.

3. *Distribution.* The Officers of Engineers (except the Staff) were in 1846 distributed in 22 Home Commands, 20 Foreign Commands; 2nd Captains with 1st, and 2nd Lieutenants attached to the Royal Sappers and Miners; besides several Officers employed on the Topographical Surveys of Great Britain and Ireland. The general distribution of the Companies of Sappers and Miners in 1846 was, 2 at head-quarters in course of instruction, 3 Companies attached to the Topographical department, 2 Companies at home, and the remaining Companies in the Colonies.

4. *Administration.*† In both Corps, and subject to the Master-General of the Ordnance, this is immediately under a Chief Engineer or Inspector-General of Fortifications, assisted by an Assistant Adjutant-General.

In reference to the Engineers, the term 'Administration' implies organization, distribution, discipline, and the practical part only of education, the theoretical portion having been effected at Woolwich. The three first are disposed of at the Head-Quarter Office in Pall Mall; the fourth and last at the Establishment for Field Instruction at Chatham, where the Junior Officers are instructed in sapping, mining, pontooning, construction of batteries, and siege-works in general, besides practical architecture and astronomy, as well as surveying.

In regard to the Sappers, the 1st, 2nd, and 3rd, as well as instruction in regimental duties, are in the hands of the Brigade-Major of that Corps at Woolwich. When at the Chatham Establishment, the education is completed to the extent of sapping, mining, pontooning, construction of batteries and siege-works, besides, to a certain extent, practical geometry and geometrical drawing.

The Sapper is at all times equal and liable to all the ordinary duties of an Infantry soldier, besides those of a mechanic in the various duties peculiar to the corps.

5. *The Special and Ordinary Duties* of both corps — conjointly or severally — comprise the execution of all military works, such as fortifications, magazines, and storehouses, which are termed 'Ordnance' works; all buildings for the accommodation of the troops, and commissariat buildings,—these are termed 'Barrack;' and this

* Provisionally 28 in Ordnance Estimate 1846-47.

† Contrary to Artillery System, which has only one place of instruction, discipline, and concentration.

constructive branch of the Engineer Service is under the inspection and direction of the Chief Engineer, as well as under the superior control of the Master-General and Board, who examine all projects and estimates, and finally give instructions for their execution, whether these military works are constructed at home or abroad, if the funds are provided by the British Treasury.

6. *Duties in the Field.* In the field the Royal Sappers and Miners are either workmen or sub-directors, the latter more especially when employed in the trenches, the construction of batteries and bridges, or as mechanics; and very much of the success of the operation, when thus associated with other troops, depends on their skill and the sufficiency of their numbers.

The duties of the Officers of Engineers are so multifarious that it is scarcely possible to define them. On active service, sometimes he is a Sapper officer, at another a Local Engineer in the construction of works and bridges; at other periods he may be employed in the reconnoissance of a country, or attached to a General Officer as Engineer of the division of an army. At sieges,* the whole corps in the field is generally absorbed. The distribution of the Engineer Officers with the army in Spain in 1813 † will explain the occupation of the corps in the field, where about 40 officers were employed.

5 were at head-quarters, including Chief Engineer and Staff.
8 attached to divisions of Infantry.
3 with the Pontoon train.
12 with 4 companies of Sappers.
4 'Ingénieur du Place' repairing fortresses.
5 employed in the Lines of Lisbon.
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37

The course of duty assigned to the Officers of Engineers on joining the army was usually inversely to the above arrangements, and they commenced in the Lines of Lisbon: the highest distinction was that of being attached to a General Officer ‡ of Division, which was given without reference to his rank, but on his experience with the army in the field. The extraordinary or mixed duties of Engineer Officers are when they are employed in connection with Civil, Naval, Artillery, and other Military Officers on special services, which are of frequent occurrence.

7. *The detail of duties* of the different commands at home and abroad, sometimes held by a Colonel, or by a Captain, according to the extent and responsibility of the command, assisted by other Officers of Engineers, and a Civil branch of the Engineer Department, well versed in construction of buildings and framing estimates and drawings. The latter branch consists of Clerks and Foremen of Works, appointments which correspond with the Gardes du Génie of the French Service, and like them they are classed according to their services, zeal, and talents. Abroad, in these duties they are assisted by the Sappers and Miners, whose services are there invaluable; § at home, where the work is chiefly executed by contract, except in the construction of fortifications, the superintendence is confined to the Clerks and Foremen of Works under the Engineer Officers. The Engineers are not accountants of money or (generally) of stores; they have only to certify to the expenditure of each when the disbursements are made by an Ordnance or Treasury accountant: hence it will be

* See Articles 'Attack of Fortresses' and 'Battery.'

† Exclusive of the Army in Catalonia.

‡ To afford professional assistance in reconnoissances, in the passage of rivers, in the attack and defence of posts and villages, destruction of bridges, in the execution of intrenchments prior to an engagement, and occasional assistance as Staff Officers.

§ *Vide* last paragraph of this Article, extracted from the 'Journal des Sciences Militaires.'

seen that the Department has no interest in any public expenditure, neither does it derive any pecuniary advantage in the execution of public works.

8. *Historical Reminiscences.* It appears that prior to the Peace of 1763 the duties of Engineers were executed by Officers taken from the army, in the manner in which those for the Staff are now selected, and the operations at the sieges of Louisburg, Belleisle, and Quebec were conducted by Engineers so selected, the Artillery then constructing their own batteries. Between 1763 and the American War, the Engineers were organized into a permanent corps, those Officers who had served as such having the choice of remaining or returning to their Regiments, when the junior ranks were filled up from the Royal Military Academy at Woolwich; but prior to this organization, that military school only furnished candidates for the Royal Artillery.* About the Peace of 1783, the corps was raised to the rank of a Royal Corps, and the uniform changed from red, faced with black velvet, to blue and black, at the suggestion of Charles, third Duke of Richmond, who established a code of regulations for the Ordnance and Engineer Departments, still in existence, and remarkable for their simplicity and arrangement. Consequent upon the war of 1793 and augmentation of the army, as well as increase of the Colonies, the corps of Royal Engineers has been gradually increased from two battalions of Officers to six; and the corps of Sappers and Miners, from several Companies of a sedentary corps of Artificers, was in 1812 (when both corps had their uniform again changed to red, faced with blue velvet,) converted into a body of men well versed in the general duties of engineering, sapping, and mining, as well as their peculiar trades of carpenters, masons, and smiths,—a system organized by Major-General Pasley, who had the direction of the practical instruction at Chatham for about thirty years.

9. *Conclusion.* From this brief description of the corps of Royal Engineers and Royal Sappers and Miners, and their several duties and position with the rest of the army, whether sedentary or active, it will be seen that the organization corresponds, as in other Services, with the nature of our military institutions, although† the Ordnance Branch in the British army is a peculiarity difficult to understand, as at variance with the composition of other armies, where the Minister of War is the supreme and controlling head. In comparing the Personnel of the French and British Engineers, an extraordinary disproportion will be observed between the senior and junior ranks of Officers: in the former the junior Officers are only one-third, in the latter they consist of one-half; an arrangement most injurious to the Service, when rank is essential, from the isolated nature of an Engineer's duties, to give due weight to his position and opinions.

In respect to the Administration of the British Engineer Service, there seems a want of progressive and central education at Chatham, after Officers return from abroad, and sufficient means of mutual instruction at that station, where the experience of each may be made generally known; and where a strict scrutiny‡ should be made as to the health, qualifications, and aptitude for business of every Officer after a certain service commensurate with the advantages he has received. But still, however, what is chiefly required is to place the officers or men at an early period in an active and responsible position, when they will become all that is sufficient in our Service with the probationary studies they generally receive; but the nature of Colonial and detached service does not always render this possible, and hence the

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* From January, 1770, to December, 1799, the Engineers were chiefly taken from the Artillery as already Commissioned Officers.—*Editors.*

† See the Article 'Ordnance.'

‡ See notice on this subject in Section III.—the Prussian Engineer.

necessity of a re-union at Chatham, or any other head-quarter station, where some Officer of high authority might be the controlling power, similar to the existing Artillery arrangements at Woolwich.

SECTION II.

THE ENGINEERS OF THE HONOURABLE EAST INDIA COMPANY'S SERVICE.*

The Corps of Bengal Engineers originated in the appropriation of Officers from other branches of this Service to the performance of Engineer duties, with such supplies of tools and stores as could be spared from the Artillery Park. In the course of time, Cadets for this Service of the East India Company, in the Ordnance Departments, were received for education at the Royal Military Academy, Woolwich; whilst others were deemed eligible, educated at private establishments, but subjected to examination by the Examining Officers of the Royal Military Academy. These proceeded to India, for the Artillery or Engineer Services generally; and thence the seniors were allowed the option of filling up any existing vacancies in the battalion of Officers, thus forming the Engineer Corps, after having done duty with the Artillery for from 6 to 12 months. Sometimes a further examination took place, and the selection was made by Government, when the Cadets were finally posted. This continued till 1809, when the present Addiscombe Establishment was formed, after which no nominations for training elsewhere were made. From Addiscombe, at first, the Cadets went to India as before, for the Artillery or Engineers; but at the end of a year, the first step in improvement was made in making the selection for the different branches in England, and retaining those appropriated to the Engineers for further instruction in the special duties they would be called on to perform: this was followed by the East India Cadets being admitted to all the benefits of the course of practical instruction at Chatham, and such continues to the present time. In India, the duties expected to be performed by the Engineer Corps of Officers (for a long time there were no men attached to them) are multifarious. In times of peace, they are expected to be competent in every branch of civil engineering, not only theoretically but practically, having often to instruct the artisans in the best mode of performing their work. They are supposed to be able accountants, having often intricate details of accounts to manage, they being always executive officers in charge of all the details of expenditure. They are further supposed to be capable of surveying in any requisite degree that the public service may demand; and, under the name of Garrison or Executive Engineers of Districts, are in charge of all the fortifications and public works generally, including roads, bridges, and irrigation canals, though there are necessarily exceptions, from the relative paucity of officers compared with the work to be done. In the field, the duties, on the first establishment of the Corps, were performed in the best manner that circumstances permitted, by one or two officers attached to a division, without men. The first step of improvement was the formation of a Corps of Pioneers, officered from the Line; they were a highly useful and gallant body of men, but deficient in the training requisite for engineer soldiers. At or about the same time, a Miner Company of about 200 men of all classes was recruited from the Native Military Miners of Upper India. They were under very little discipline, with no training beyond their own traditional practice, and when not in the field, were put under the Staff Officer of the station they might be at. The Officers of Engineers never saw any thing of either the Pioneers or Miners, except

* By Lieut.-Colonel Colvin, Bengal Engineers. Given by this Officer as referring exclusively to the Bengal Presidency; but the organization of the Madras and Bombay Engineers is similar.—*Ed.*

when they met on field service, and there was, consequently, a good deal of mutual ignorance of each other's mode of proceeding, not favorable to the public service. These considerations led the Indian Government to decide on the commencement of the present system, and the Corps of Sappers and Miners was directed to be organized by Captain R. Tickell, (now Major-General R. Tickell, C. B.,) the Officer in the Corps (then of the strength of 2 Battalions, or 40 Officers) who had the greatest experience in field duties. The old Company of Miners was taken as a nucleus; volunteers were admitted from the Corps of Pioneers, and fresh men were enlisted for this particular service. They were formed into a regular Corps of 6 or 8 Companies, with a non-commissioned European Staff trained at Chatham, and young Officers of the Corps of Engineers attached to them. The duties and practice of the Corps were conducted on the same system as in the Royal Engineers, and a very efficient Corps of Sappers and Miners formed. This was soon followed by the abolition of the Corps of Pioneers, whose duties devolved upon the new Corps, which became a good deal dispersed about the country, and were employed on work heretofore performed by the Pioneers in times of peace. This has greatly interfered with the very efficient system of practical education commenced; but the Corps has been more and more drawn together again, and is, probably, benefiting by a more extended practice in their most essential branches of training. There still, however, exists the great defect of a want of mutual acquaintance between the Officers of the Corps (now 92 in number, or strength of 4 Battalions) and the men. It is the custom for young Officers, on first reaching India, to be posted to the Corps of Sappers and Miners, with which they do duty for one or two years: this, however, is not universal, (a late Order places them for three months with a department in Calcutta, to learn the theory and practice of forming iron bridges and roofs.) From the corps they are appointed Assistants in executive departments, in which they continue and rise, and hardly ever return to the Sappers, or see any thing of them, or have any practical experience in field duties, except when in the field, when the Engineer Officers nearest at hand are called in, and in camp meet with a detachment of Sappers under their own Officers. They certainly meet with men well trained, accompanied by an efficient non-commissioned European Staff, tending greatly to expedite and simplify all field or siege operations; but it appears an evil, when such care was taken in the formation of the corps, that a batch of Officers were not attached to them, of which a portion should be annually relieved, so bringing the whole corps of Officers in contact with the men, under a practical course of military engineer duties, at least once in eight or ten years, instead of, as now, never after their first outset in the Service.

The general duties of the Corps are presided over by the Chief Engineer quartered in Fort William.* He has, however, little position or power beyond that of being, *ex officio*, a member of the Military Board, to which every Executive Department of the military service in India is subordinate. In the field, the Officers called on for service are nominated to be Principal Field Engineers, Field Engineers, or Assistant Field Engineers. When sufficiently numerous, they are brigaded, with a suitable Staff; but generally the duties are conducted by a Field Engineer, with one or two Assistants. These Officers report direct to the Chief Engineer; but for supplies of tools or stores for working parties beyond what the Sappers may have, they apply to the Military Board, through the Officer in charge of the nearest magazine, who is bound to comply with his indents at once, if he can. In Civil duties, the superintendence, not of the Chief Engineer, but of the Military Board, reaches the Executive Officer through the Superintending Engineers of Circles, who have no executive duties,

* In the Bengal Presidency.

but power to see that all such are duly performed by the Executive Officers and their Subordinates. The power of appeal against any decision of a superior exists to the Governor-General in Council, and even to England; but any appeal beyond the Chief Engineer or Military Board is of very rare occurrence. The foregoing remarks apply exclusively to the Corps of Bengal Engineers, and not to those of the Madras or Bombay Presidencies.

N. B. In 1826 the strength of the Corps was increased to 3 Battalions, and in 1844 to its present strength, as given.

4 Colonels,
4 Lieutenant-Colonels,
4 Majors,
20 Captains,
40 First Lieutenants,
20 Second ditto.

The Sappers and Miners 10 Companies of each—

2 Serjeants, 2 First Corporals, 2 Second ditto, 2 Privates,	European.
1 Subadar, 1 Jemadar, 4 Havildars, 8 Naicks, 2 Buglers, 120 Sepoys,	Native.

SECTION III.

Das Preussische Ingenieur-Corps.*

The Prussian Royal Engineers form one corps, under the command of the Inspector-General of Fortifications.

It is divided into two parts.

A. Engineer Officers.

For the construction of Fortifications and Military Buildings, who also in time of war take the field; and in war or peace are liable to regimental duty with Sappers. As all these Officers are available for any of the above duties, they must be qualified accordingly.

B. Sappers.

Non-commissioned officers and privates of Sappers. Their duties are—sapping, mining, and pontooning. They are commanded by Engineer Officers, who are temporarily attached to them.

The Officers who in peace are charged with fortifications and military buildings, are, together with their respective fortresses and garrisons, told off into six Fortification-Inspections or districts, each under an Inspector of Fortifications, whose responsibility extends to personnel as well as materiel, and who has the rank and pay of the Colonel of a regiment. Every station has its Commanding Engineer,† either a

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* Communicated by two German Officers of rank, and translated by Captain Nelson, R. E., with the exception of the last four paragraphs, which, with a few very trivial modifications, are given verbatim from the MS.

† "Platz-Ingenieur." There are several terms in the German which cannot be literally translated with accuracy: hence, in the following pages, 'Sappers and Miners' has been substituted for 'Pionier;'—the 'Ingenieur-Inspecteur' is our (once!) Deputy-Inspector-General; whilst the

Major or a Captain, and one or more other Officers, Captains, or Subalterns, according to circumstances.

In war time, a certain proportion of these Officers is transferred to the army in the field.

The Sappers are divided into nine divisions of two companies each, each division forming the proportion for one of the nine * corps d'armée.

Each Company is subdivided into four sections.

1 Miners.
2 Sappers.
1 Pontooneers.

In time of peace the Sappers of three Divisions (or of three corps d'armée) are under the command of an Inspector of Sappers,—a Staff Officer, who, like the Inspector of Fortifications, has the rank and pay of a Colonel, and who is responsible for the education and training of his men.

Two 'Fortification-Inspections' or districts, and one 'Sapper-Inspection,' together form the charge of a Deputy Inspector-General, who has the rank and pay of a Major-General.† Hence these three Officers, combining the control of Engineer and Regimental duties, preside over the three grand divisions of the Prussian Engineer Service.

In time of war these Officers take corresponding command in the field.

According to the necessity of the case, in event of war, the different Sapper divisions are brought to their proper strength by combinations, exchanges, &c.; but they remain under their own regimental Officers, always disposable for Engineer duties, and under the command of the senior Engineer.

Although the Sapper Companies are organized with reference to mining, sapping, and pontooning, yet each section (as detailed above to these duties) receives a specific instruction; and in the execution of any one of these functions the men of the remaining sections act as assistants only. The non-commissioned officers are only occasionally changed from the section in which they have first received instruction or have imparted it to others; the expansion and completion of their education is left to what they can learn at the annual exercises in siege operations, when they act in combination with other troops.

The senior Officers superintend these courses of instruction; the junior Officers (who serve at least three years as regimental subalterns) are in many respects teachers, in others pupils: as the former, they impart such theoretical knowledge as is necessary to the serjeants; as the latter, more especially in their relation to the military service in general, and the technical part of their own more immediate profession in particular.

After going through this complete practical course as a school of application, the young Officer is first transferred to fortification duties; and from thence, on reaching the rank of first Lieutenant, back again to the Sappers to learn the duty of commanding a company: here he remains, as to time, partly on rotation, partly according to the display of greater or less ability, eventually reaching the step of Commander

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'Fortifications-Inspecteur,' and 'Pionier-Inspecteur' have been rendered literally, as we have no such functionaries.—*Translator.*

* Undisturbed by the arrangements necessary for Colonies, or for very detached European possessions, a remarkable degree of symmetry has been practicable in the distribution and organization of the Prussian Army; that of the Engineer Corps is of course conformable. For a detailed account of these subjects, see the 'United Service Journal,' Sept., Oct., Dec., 1839.—*Translator.*

† 'Brigade Commandant;'—the word 'Major-General' has various meanings in different Services; it is given above in the English sense, as commanding a Brigade.—*Translator.*

of a Sapper division, who ranks with Chef-de-Bataillon, and also with the Commanding Engineers of Fortresses, in pay and seniority.

The Engineer Staff consists of all those Staff Officers of the corps who either are posted to the higher fortification or regimental commands, or of those who are destined to hold them.

Promotion* to the ranks of Colonel and Major-General is dependent solely on qualification: the Officers who have held regimental appointments will generally have had sufficient acquaintance with fortification duties, and vice versâ, to be conversant with the details of these two branches, by the time they reach the rank of Deputy Inspector-General, whose authority extends to both.

Should a First Lieutenant fail in his examination for the rank of Captain, he is transferred to any other branch of the Service for which he may shew particular aptitude.

Suitable qualifications in the different branches of the military service may advance any one in the Prussian Service to the rank of an Officer: though not without example, this is rarer in the Engineers than in other corps; yet when it did occur, it was in times when there was a deficiency in early training in such professional matters as were indispensable, but which in later times is scarcely likely to occur.

First entry and subsequent promotion is, therefore, in time of peace dependent on acquirement; and this principle is continued with that of occasional "purification."

In the first instance the candidates bring the same stock of school knowledge as is necessary for other Services; and after a satisfactory examination,—that of Ensign,†—he goes as volunteer to a Sapper Company, where he remains until admissible to the Artillery and Engineer School, though he must previously remain at least a year in the Sapper Company to be well drilled. He repairs to the Artillery and Engineer School with his Ensign's testimonials, and according to his greater or less proficiency and zeal (as well in military subjects as in *Humaniores*), he is either *appointed* Ensign in the course of a year, or is sent back to his Company. At the end of the second year of instruction, if recommended by conduct, and advance in studies, he receives the pay of an Infantry Officer, though this has nothing to do with his rank in the Corps. In this second year also, the Specific Corps Instruction is commenced, and continues until the end of the third year, when, on final examination, he receives his Engineer Commission, and is posted to a Sapper Division as Second Lieutenant.

There exists no especial and printed account of this subject: as embodied in the above, it has been composed from fragmentary notices, and it is only of late that an effort has been made to re-arrange and elaborate the older regulations of the Prussian Corps of Royal Engineers.

PEACE ESTABLISHMENT OF THE PRUSSIAN CORPS OF ROYAL ENGINEERS.

(A.) *The Officer Corps consists of,*

1 Inspector-General of Fortifications, ranking either as General of Infantry or as Lieut.-General. 3 Deputy Inspector-Generals of Fortification, ranking as Major-Generals, or as Colonels.	With 9 Adjutants; 5 of whom are from the strength of the Corps, the rest from the 'Adjutantur.'
6 Inspectors of Fortification. 3 Inspectors of Sappers.	Ranking as Colonel, Lieut.-Colonel, or Major.
12 Staff Officers.	

* An admirable rule *if* it could be worked out fairly: in the Line and Cavalry it is *supposed* to commence with the rank of Major.—*Translator.*

† *Vide* 'United Service Journal' for 1839, p. 498.

36 First Captains,—some of whom are Brevet-Majors.
42 Second Captains.
38 First Lieutenants.
74 Second Lieutenants.

215 Besides an indefinite number of seconded Second Lieutenants on Infantry pay.

(B.) *Non-Commissioned Officers and Privates of Sappers.*

9 Divisions (or 18 Companies) of Sappers of 251 men per division, including 1 Accountant.

2 Reserve Companies of 125 men each, including non-commissioned officers.

Those attached to the War Office, those teaching in the Artillery and Engineer School, and those on foreign command, are (with exception of a few) Officers expressly seconded, and chiefly taken from the Staff; as are also the Staff Officers commanding in Fortresses, the Adjutants attached to the Inspector-General and Deputy Inspector-Generals of Fortification, and those to the Divisions of Sappers.

REMARKS.

1st. To meet the demands for Engineers in case of war, the Corps possesses an unlimited resource in the Landwehr Sapper Officers.

2nd. The proportion of Engineers for a fortress of the first class in time of war is about

1 Officer of the Staff,
1 First Captain,
3 Second Captains,
3 First Lieutenants,
4 Second Lieutenants,

and this, as a basis, would be modified according to the size and position of the fortress, with reference to the theatre of war.

3rd. The Conscripts for the Sappers are taken from such mechanical pursuits as are in themselves a preparation for their future military service;—miners, masons, carpenters, sailors and fishermen, rope-makers, smiths, &c., all of them in a proportion fixed for each conscription ballot.

The above-mentioned force (A and B) is the peace establishment: it is composed of the men serving in the standing army a period that lasts five years, including two years reserved furlough. After this period they remain liable to the Landwehr during seven more years, during which they are called in every two years for a drill of fourteen days. The Landwehr, in time of war, doubles the peace establishment.

The Officers of the Landwehr are composed of such as have served in the Engineers for a longer or shorter time, and remain liable to be called in for service in time of war, after having quitted active service to enter some civil branch of the profession. There are now 2 Captains, 6 First and 46 Second Lieutenants, on this footing.

Examinations are to be passed, 1st, before entering the Service as an aspirant; 2nd, in the School; 3rd, before leaving the School; and then before the promotion from First Lieutenant to the rank of Captain. This last examination is more of a practical than of a theoretical character; it is intended to prove that the future Captain has converted *in succum et sanguinem* the different theoretical and practical studies of his profession, and has the experience and judgment to put them in practice.

SECTION IV.

CORPS DU GÉNIE DE FRANCE.*

Organization.—(Order, 13th December, 1829.)

Composition.—The Corps Royal du Génie is composed of—

1st. A Staff, including
- 12 General Officers,
- 400 Officers of the Staff (24th September, 1831), and Candidates for the Engineers,
- 9 Professors in the Regimental Schools,
- 500 Gardes du Génie,
- 6 Ouvriers d'E'tat.

2nd. The Regimental portion.
- 3 Regiments of Sappers,
- 1 Company of Workmen,
- 1 Company of Veterans, (19th November, 1831.)

Staff.—The 12 General Officers are, 1 Lieutenant-General, President of the Committee of Fortifications; 3 Lieutenant-Generals, members of the Committee; 8 Major-Generals, members of the Committee.

The 400 Staff Officers are composed of (24th September, 1831) 25 Colonels, 25 Lieutenant-Colonels, 72 Majors, 140 1st Captains, 138 2nd Captains and Lieutenants; Total, 400. These are selected exclusively from among those who have passed through the School of Application.

Every year, the Minister of War (according to the vacancies to be filled up in the corps) determines what number of pupils from the Polytechnic School ought to be admitted to the School of Application with the rank of Sub-Lieutenant.

After two years of study these Sub-Lieutenants of Engineers undergo final examination. Those who give proof of sufficient knowledge in the necessary acquirements are gazetted in the corps, according to their rank of merit determined by the examination; they are then appointed to the Regiments of Engineers (or Sappers and Miners) to perform the duties of Second Lieutenants. By this means two-thirds of the vacancies which occur in these regiments are filled up by them.

Such Engineer pupils as, not having been deemed worthy of appointment to the corps of Engineers after two years of study at the School of Probation, have passed a third year there, take rank with those who leave the same year as they do, and are gazetted according to the degree of merit ascertained by the examination, and they have no right to the rank of Lieutenant before these same pupils. Those who, after their second decisive examination, are found unfit for admission to the Corps of Engineers, are sent away from the school.

Officers of Engineers, besides those admitted to the Corps according to the foregoing qualifications, are liable to be received directly at the School of Probation, until the age of thirty years, after having undergone an examination, the programme of which is determined by the Minister of War.

The Examiner of the Engineer pupils is appointed by the King, on the recommendation of the Minister of War.

The Professors in the regimental schools of Engineers are appointed by the Minister of War, proposed by an Inspector-General of Engineers, after having undergone an examination before a Commission presided over by that Inspector.

The Gardes du Génie,† 500 in number, are divided into 3 classes, viz., 120 of the first class, 180 of the second class, 200 of the third class; total 500.

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* Abridged from the 'Aide-Mémoire de l'Ingénieur Militaire,' par Grivet, 1834. Translated by Lieut. De Butts, R. E.

† Corresponding to the Clerks and Foremen of Works in our Service.—*Ed.*

The Minister of War determines the number of these Gardes, from selections made exclusively by the Inspector-Generals of Engineers. They are taken as follows: those of the third class from among non-commissioned officers of the Sappers and Miners who have served at least six years; those of the second class from among the Gardes of the third class, having had at least three years of service in their class; and those of the first class are chosen from the Gardes of the second class who have been two years in the service in their own class.

"Les Ouvriers d'E'tat," composed of a Governor, a Sub-Governor, and four workmen, are named by the Minister of War on the conditions prescribed in the warrant of the 24th April, 1822.

Sappers and Miners.—Each of the three Engineer regiments is formed,—1st. Of two battalions, each battalion containing 7 companies of Sappers and 1 of Miners (17th November, 1830). 2ndly. Of an Unattached Company. 3rdly. Of a Waggon Train (28th June, 1832).

In time of war, a dépôt is formed of two skeletons of companies from each regiment.

Men intended for the Engineer regiments are required to be strong, of good constitutions, and to be at least 5 feet $6\frac{1}{2}$ inches high (English). They are selected in the following proportions:—

$\frac{5}{30}$	from among	Carpenters.
$\frac{3}{30}$	"	Masons.
$\frac{2}{30}$	"	Smiths.
$\frac{20}{30}$	"	Excavators.

GENERAL DUTIES OF THE CORPS DU GÉNIE IN TIME OF PEACE.

In time of peace the Officers of Engineers are distributed throughout the interior of France and in the different colonies.

The following are their particular duties:—

1stly. Correspondence and maintenance of the personal relations which exist between Commanding Engineers and the different Civil and Military authorities.

2ndly. Establishment and preservation of the different papers, stores, &c., &c., and those articles which are under the special superintendence of the Engineer of the station; the purchase of the necessary articles, and giving them over for public sale when no longer serviceable.

3rdly. To represent Government, in conjunction with the Military Superintendent, for the acquisition, sales, or cession of ground and military buildings, as well as fixing boundaries to military properties; to take leases of these properties, to rent others for the service of the State, and to obtain payment for damages done to Government property and to military buildings.

4thly. To superintend every thing relating to military buildings.

5thly. To make plans and elevations of fortified places, and the country surrounding them; to report thereon, and on the defence of the neighbouring country; to devise plans for the better protection of such places; to make surveys and military reconnoissances; to draw up reports conjointly with the "Ingénieurs des Ponts et Chaussées," relative to works which these last propose to execute along the frontier, and the approval of which depends on a Committee composed of the principal Officers of those two Services.

6thly. To make plans of all military buildings, and records of "Construction" and "Occupation."

7thly. To draw up details and specifications of different works, and carry them into execution when ordered, whether fortifications or military buildings; to estimate

for them, and to send the expenditure accounts to the Minister of War, when finished; to draw up at the end of every year projects for works to be executed in that ensuing.

PERSONAL DUTIES.

1. In each station there is a Commanding Engineer, having under his orders one or more Gardes du Génie, or persons in charge of military works, and sometimes officers of a rank inferior to his own. As all the work devolves upon the Commanding Engineer, it is by alluding to him that we intend to describe the different functions and relations of his superiors and inferiors.

2. Commanding Engineers are alone responsible for what is done in the stations where they are placed; their inferiors are responsible to them. Nevertheless, when projects are made, the Officer who frames and signs them, whatever be his rank, shares with the Commanding Engineer the credit or the responsibility, though the latter approves of them by placing his signature thereto.

3. Commanding Engineers do not correspond direct with the Minister of War. All the documents and plans which relate to their service are first of all addressed to the District Director of Fortifications, who resides at the head-quarters of the district. This Officer lays them before the Minister, with his own notes and remarks; and the decision of the Minister is made known, through the same channel, to the Commanding Engineers.

4. The Directors of Fortifications have the following especial duties: 1st. To give their advice and experience to Commanding Engineers. 2ndly. To obviate on their own proper authority many of the difficulties which may occur in the execution of the works, and for which the opinion of the Minister would be too slow, or not sufficiently detailed. 3rdly. To inform the Minister precisely of every thing which bears a relation to the defence of the frontier. 4thly. To act as an intermediate authority between the Minister and the Commanding Engineers.

5. It follows from the evident importance of the situation of Director of Fortifications, that generally all documents of work proposed in the office of the Commanding Engineer should be made in triplicate—one for the Station, one for the District, and one for the Minister.

6. The Director of Fortifications should pay every year at least two visits to the stations in his district: one in the spring, to set the works ordered a-going; and another in the autumn, to witness the execution of them, to check and sign the measurements, and discuss with the Commanding Engineer estimates to be brought forward in the ensuing year. When the works are but few in number, or of no great importance, the Directors pay but one yearly visit, in the autumn.

DUTIES OF THE CORPS DU GÉNIE IN TIME OF WAR.

1. When in the field, l'E'tat-Major du Génie is generally composed of a General Officer, who takes the title of "Commanding Engineer of the Army;" a General Officer, Chief of the Staff; a Superior Officer, Director of the Park; in fact, of a greater or less number of Superior and Inferior Officers, as well as Gardes du Génie, according to the wants of the Service.

2. To every Division of Infantry is attached a Commanding Engineer, of the rank of at least First Captain.

3. If an army be formed to act separately, a Commanding Engineer is attached to it (who may only be a "Superior Officer"), or Chief of the Staff, and a Chief of the Park (if there be one), who may be only Captain.

4. The Engineers attached to the army are employed on works of permanent fortification, on those for the attack or defence of a place, and on those of such reconnoissances as are entailed by such works.

5. They may also be required to construct the field-works which the Generals of the Army or of the Divisions may think fit to establish, such as attacks and approaches, redoubts, small forts, blockhouses, têtes-de-pont, intrenched lines and camps, dykes, &c.; also works on the march, such as opening communications, the construction or demolition of roads, bridges, &c., &c.

6. General Officers and Officers of all ranks in the Engineers, who are not attached to a company, form part of the Staff of the Army, of the Corps d'Armée, or of the Division to which they are attached.

7. Every Commanding Engineer receives direct, or through the Chief of the Staff, the orders of the General Officer to whom he is attached; he informs this General of the orders given to him by the General Officers of his own Corps.

8. When it is necessary to establish permanent garrisons in places, or military posts, either conquered or formed by the army, the Engineer Service takes in these places or posts the same duties as at home stations.

9. Officers of Engineers are forbidden to communicate to any other person, except to the General of the Army, or to the General Officer to whom they are attached, or his Chief of the Staff, the state of the supplies, &c., or the plans of places, or of works executed or in execution.

10. The composition of all armies is that of Divisions. This principle of several divisions under one Commander composes either an army, a wing, or a centre of an army, or a reserve. The division is generally formed of two or three brigades, either of infantry or of cavalry; it includes troops of different services in the proper proportion.

TROUPES DU GE'NIE.*

Les troupes du génie sont composées de sapeurs et de mineurs. Elles ont généralement pour destination d'exécuter toutes les constructions nécessaires pendant la guerre; de rétablir les fortifications de toute nature, tant sur les postes isolés, que sur les principaux débouchés et dans l'intérieur du pays; de détruire tous les ouvrages de cette nature appartenant à l'ennemi, lorsque cette destruction n'a pu s'effectuer entièrement par le feu de l'artillerie; de réparer ou de construire les ponts fixes, les digues et les routes ou autres moyens de communication; de les détruire s'ils nous sont nuisibles. Les troupes du génie doivent donc aider à détruire tous les obstacles naturels ou artificiels qui servent à la défense, ou à les construire s'ils deviennent nécessaires. Les soldats du génie sont par conséquent plutôt des ouvriers que des combattants, et ils ne portent des armes que pour leur défense personnelle; car pendant leurs travaux, ils sont protégés par d'autres troupes. Cependant, ce serait commettre une grande injustice, que de ne pas placer cette classe si estimable de soldats au même rang que les grenadiers, les cuirassiers et les canonniers; car il ne suffit pas que les troupes du génie exécutent avec adresse et célérité les travaux qui leur sont ordonnés; mais elles sont presque toujours obligées de le faire dans des circonstances difficiles, et même sous le feu de l'ennemi; ce qui exige un grand sang-froid et une intrépidité égale à celle qu'on peut désirer des autres soldats.

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* From No. 73, third series, of the 'Journal des Sciences Militaires, p. 99.

ENGINEER, CIVIL.

SECTION I.

ENGINEER, CIVIL, GENERALLY.*

This profession may almost be said to have originated in England within the last century. Before the middle of the last century, whenever the prospect of great profit induced individuals or bodies corporate to undertake extensive systems of drainage, and for this purpose to call for the assistance of an engineer, recourse was generally had to those great masters of hydraulic engineering, the Dutch. True it is that some solitary exceptions have occasionally been found; men who, like Sir Hugh Middleton, combined a speculative turn of mind with some mechanical knowledge, and to these two qualities added an untiring energy of purpose leading them to persevere in any undertaking, even under the most discouraging circumstances. But these men were rare instances of a peculiar talent, which, though it thus displayed itself occasionally, was far too uncommon a gift to allow the possessors of it to form a class or profession. The case is very different now: a demand for this peculiar talent has been created of late years by the extraordinary development of our system of internal communication, as well as by the application of steam to the purposes of our manufactures; and employment is now found for hundreds where one was sufficient not fifty years ago for the whole business of the country. So great indeed has been the demand, that the profession may be said to be divided into two distinct bodies, viz., those who turn their attention to those subjects which come more particularly within the scope of the duty of a Civil Engineer, such as docks, bridges, canals, rail-roads, &c., and those who devote themselves altogether to the manufacture of machinery. The duties which are involved in the practice of these two branches of the profession, though apparently dissimilar in character, are yet founded upon the same general principles; and the acquirements which are necessary to enable the individual of one class to distinguish himself, or even to practise his profession with a moderate chance of success, will be found equally necessary for those of the other class.

These acquirements are partly abstract and theoretical, and partly experimental or practical. A Civil Engineer should, in addition to the knowledge required to fit him as well as others for the active duties of life, have such a knowledge of mathematics as will enable him to investigate as well as to apply the rules laid down by writers on those branches of the mixed sciences to which his attention will most frequently be drawn. He should be well acquainted with the principles of mechanics, hydraulics, and indeed with all the branches of natural philosophy: a certain amount of chemical knowledge will be found very valuable; he should be able to draw neatly, and should understand the principles of projection upon which all engineering drawings are constructed; a general knowledge of the principles of architecture will also be essential. Having acquired the requisite amount of theoretical information, the next step is to gain that practical knowledge which is essential in order to the proper application of this information. The best mode of gaining this experience is to enter into the employment of some eminent man in the profession, in whose office there will be every opportunity offered to the young beginner of witnessing the mode in which the various descriptions of work are carried on. He will there be employed, first as a draftsman, in copying drawings; as he becomes more acquainted with practical details, he will have more responsibility thrown upon him,

* By Capt. Denison, R. E.

and be placed in charge of works, at first of small importance, but, by degrees, of those of such magnitude as will require all his theoretical knowledge, and all the practical experience he may have gained, to enable him to carry out the work to the satisfaction of his employers: he should cultivate a habit of observation, and make a point of taking ample notes and sketches of whatever he may see which in any way bears upon his profession. Having thus by degrees acquired a sufficient amount of information to give him a confidence in his own judgment upon any subject which may be submitted to him, and having become known as an active and intelligent agent of others, he will very possibly be called upon to plan and execute a work himself, and then, by degrees, with industry and activity, may work his way upwards in *a profession where merit alone can lead to distinction.*

The course of the man who devotes himself to the machinery branch of the profession differs but little, up to a certain point, from that just described: his theoretical acquirements should be the same, but the practical part of his education will commence at the bench, where he will learn the use of all the tools and machinery by working at them with his own hands: he will then be placed in the drawing room, and go through much the same routine of instruction as before described, and will by degrees work his way up to the position of foreman; then, distinguishing himself by a power of applying general principles to particular cases, will shew himself capable of assuming the direction of an establishment for the manufacture of machinery.

SECTION II.

ENGINEER, CIVIL—STEAM-BOAT.*

A Steam-Boat Engineer is a person employed to keep the steam engine or engines of a steam vessel in as efficient a state as possible, and to superintend their working.

He must set the engines to work, regulate their speed, and stop them as may be required. His duties while the engines are at work are various. He must take care that every moving part is properly lubricated; that no steam is allowed to pass through valves or joints that ought to be steam-tight; that no air is permitted to enter into any of the parts of the engine where it is essential that a vacuum should be kept up; and that none of the bolts, or pins, or keys work loose by the vibration, and shift their position, or come out of their places. He must also take care that none of the working parts become overheated by any undue amount of friction, arising from any want of proper lubrication, any excessive tightness, or any other disturbing cause; and if they should become overheated, he must take prompt and energetic measures to remedy the evil, and prevent any serious consequences arising therefrom. He must from time to time carefully observe the effect produced by the gradual wear of the working parts, so that if the truth or accuracy of any of these seems to be materially affected, he may take steps to rectify the defects when lying up in harbour. He must also be careful to observe if the frame of the engine ever begins to move or work in any way, and endeavour to discover the cause, in order that it may be remedied when the engines are at rest. One of the most important of his duties is to take care that the engines are kept clean, and any grit or dirt prevented from getting into the bearings or moving parts: he must wipe away all oil and grease

* Communicated by Captain Denison, in connection with the preceding.

This Paper, though specifically arranged in reference to steam vessels, nevertheless gives much of the sort of routine that is generally applicable to all steam engines, mill-work, rail-road, mine-pumps, &c., &c.—*Ed.*

most carefully and completely as soon as they have passed through the bearings, and prevent them from running down the rods or remaining about the engine.

The boiler requires his unremitting and particular attention, in order that the proper supply of steam, neither too much nor too little, may be generated for the engine. To insure this, the management of the fires must be duly attended to, both in the supply of coal in the proper quantities at the proper intervals, and in the periodical clearing of the fires from the earthy matters of the coal, which may have become vitrified in the furnace, and formed what are called clinkers. By due attention to the former, the smoke in all well-proportioned boilers may be very greatly abated, and, by due attention to both, the consumption of fuel, when the engines are prevented (by a strong head wind, or by the deep immersion* of the paddle-wheels on the commencement of a long voyage) from making the proper number of strokes, and thus using the proper amount of steam, may be reduced in an equal or greater degree than has taken place in the consumption of steam. The due and constant supply of water to the boiler to compensate for the constant evaporation of the water in the formation of the steam must be assiduously attended to. Another of the most important of the duties of a Steam-Boat Engineer, during the time that the engines are at work on a voyage at sea, and the last which we shall mention here, is to attend to the degree to which the water in the boilers may become saturated with salt by the continued evaporation which is going on, and to take care that this saturation is not allowed to be carried to such an extent as that a deposition of the salt and other matters contained in sea water should take place. After the boilers have been in operation for three or four hours in salt water, so that the water in them has become brine, he ought to test the strength of it, that is, he ought to ascertain the degree of saturation to which it has reached, and continue this examination periodically, whether the engines are fitted with an apparatus for the continuous discharge of a portion of the brine, to be exchanged for a portion of sea water, or whether this system of exchange is left entirely at his discretion, to be attended to by means of the common blow-off cocks. The best test is the common hydrometer, though the thermometer has hitherto been more commonly applied to this purpose, as the brine is considered to be of a proper strength when it boils under atmospheric pressure at a temperature 2° higher than that at which the common sea water will boil at the same time, under the same circumstances.

Before coming into port, it may occasionally be advantageous to take indicator diagrams, to see whether the action of the valves *continues* to be correct; as we presume that this was ascertained to be the case, and that the completeness and effectiveness of all the parts were ascertained at the first.

The duties of a Steam-Boat Engineer, on arriving in port after a long voyage, are also various, and equally important with those he has to perform when out at sea. Immediately on coming to anchor, it is a good practice to test the tightness of the steam-valves and pistons, by putting them in such a position that it can be seen if they allow any steam to pass when it ought not to do so. If any imperfections in these the most vital parts of the engines are discovered, he must draw out the valves, or lift the cylinder covers, to get at the pistons, and rectify the defects in the best manner that he can with the means within his power. He should also occasionally examine all the interior parts of the engines, and rectify any incipient

* The avoidance of which is, of course, one great advantage of the system of screw propulsion.—*Ed.*

defects. He must now also rectify any want of truth in the parallel motion or in any of the shafts or working parts caused by wear, and tighten or make good any of the fastenings of the frame if he has found them to be loose, and put to rights any other such defects. Any parts subject to corrosion should be carefully examined, cleaned, and dried, and painted if need be. The water should be blown off out of the boilers as completely as possible, and all ashes and soot thoroughly cleaned out of the furnaces and flues as soon as possible. The furnaces and flues must then be thoroughly examined, and the slightest leak or defect that can be discovered made good; as it is especially important in a boiler to stop these defects at the first, as otherwise they spread very rapidly. No pains should be spared to discover any suspected leak of steam on the top of the boiler, as nothing tends more to corrode and destroy a boiler than this. Inside the boilers, any scale that may have been deposited from the brine having been allowed to become too strong must be removed, and the whole thoroughly cleaned out from every part of the boiler, from below as well as from the tops and sides of the furnaces and flues. The take-up, the inside of the steam-chests, and of the roofs of the boilers, which are the parts most subject to corrosion from the interior, should be very carefully examined, and after being duly scraped and cleaned and dried, they should be well painted with two or three coats of red lead, or done over with some other preservative.

The paddle-wheels should also be thoroughly examined, and any broken floats or hook-bolts replaced by new ones. The whole of the iron-work should be thoroughly scraped and cleaned, and when dry, painted with three coats of red lead, or done over with black varnish, once every four months at least. When in harbour, especially if lying in a stream or tideway, the wheels ought to be turned round every three or four days, to change the parts exposed to the action of the water, and thus prevent corrosion.

He must now also get his supply of stores made good, so as to be ready for another voyage.

To qualify an Engineer to perform these duties, he should be trained as a mechanic, and be a fair workman in iron, brass, and wood. He should be able to work not only at the lathe or vice, but also at a smith's forge. His education should be such as to make him able to keep accounts, and make notes in his log of all that occurs in the engine-room. He should have sufficient knowledge of mechanical drawing to enable him, in the event of any important part of the engines being broken when at a distance from any manufactory, to make such a drawing of it as would enable a manufacturer to replace it. He should have some knowledge of the first principles of mechanics, a general knowledge of the leading principles of hydrostatics, hydraulics, and pneumatics, without which he cannot fully understand many of the principles carried on in the engine, and on which its power depends. Some knowledge of heat, of the theory of combustion, of ebullition, and of evaporation, may also be reckoned as almost indispensable; to which should be added, if possible, an acquaintance with the subject of steam, especially as regards its temperature, pressure, and latent heat.

EPAULEMENT.—It is necessary to notice this word, from the confusion which a common misapplication of it is apt to produce. In the true sense of the term, it implies the *Shoulders* or returns made at the flanks of batteries, or at the extremities of parallels; whereas it has been erroneously used to signify the parapet itself, to which these epaulements are appended.

EPROUVETTE.*

GENERAL INSTRUCTIONS RELATIVE TO THE PROOF OF GUNPOWDER WITH GUN AND MORTAR EPROUVETTES.

1. Gun Eprouvettes are to be used at all stations for the proof of gunpowder, either large or fine-grained. The Mortar Eprouvettes are only to be used at Waltham Abbey, Purfleet, Portsmouth, and Devonport.

2. Five rounds of each quantity of powder to be proved is to be the minimum of rounds for proof in Ireland, and at Foreign Stations.

3. At Portsmouth and Devonport, five rounds also to be fired; but at Waltham Abbey and Purfleet, where proofs are so frequent, (especially in time of war,) and where the modes of proof are so well understood, three rounds will be sufficient, except in such cases as the Officers of the Department see good reason to extend the number of rounds.

4. The proof of powder in store to be made annually, at the most favorable season of the year. The reports are to be forwarded to the Director-General of Artillery, so as to be received by the end of November each year

5. As a general principle, the powder in the magazines should be classed in lots of 100 barrels, from 10 of which, taken indiscriminately, the samples for proof should be drawn: these samples are to be well mixed, and the proof to be made from the mixture. Subsequent proofs for the same lot are to be taken from ten other barrels, so that by degrees the whole of the powder in the magazine will be subjected to proof; and, as far as can be, none should be issued but such as has been proved. It is always to be understood that such barrels are to be preferred for proof as, from local circumstances, may be presumed to be in the least good condition.

6. In the event of the samples of the first ten barrels not coming up to the standard, it is clearly to be understood that the remaining 90 barrels are not to be considered equally deficient in strength without further trial.

7. When there are several magazines at any station, a proof is to be made of the powder contained in each, in the proportion of 1-10th, as before explained in No. 5.

8. In addition to the annual proofs, whenever powder is landed or exchanged from ships of war, it is to be proved as soon as received, in order that its strength as well as state may be ascertained.

9. Within the general principles laid down in reference to proofs, the Officer on the spot is at liberty to exercise a discretionary latitude; but the report is to be specific, shewing clearly what has been done, and is to be accompanied by such remarks as may be deemed proper.

10. Although the proof is to be carried on under the immediate orders of the Commanding Officer of Artillery at the station, who is responsible for the faithful adherence to these regulations, yet the returns of proof, as well as any specific reports connected with them, which may be made, are to be signed by the respective Officers, who are equally interested with the Commanding Officer of Artillery in the due preservation of the powder.

Memorandum.—The proof of fine-grained power by firing steel balls into elm boards is to be discontinued, and such powder is to be proved by the gun eprouvette only.

Office of Ordnance, 28th July, 1828.

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* For the principle of this Eprouvette, *vide* Formulæ, 'Dynamics.'

INSTRUCTIONS FOR ADJUSTING AND REGULATING THE HALF-POUNDER GUN EPROUVETTE, FOR ASCERTAINING THE STRENGTH OF POWDER AT THE VARIOUS STATIONS AT HOME AND ABROAD.

1. The frame in which the eprouvette gun is suspended is to be set horizontally in both directions by the plummet attached.

2. The trucks to be scotched, to prevent any motion by the swinging of the gun when fired.

3. Two ounces of the powder to be proved is to be accurately weighed, and then placed in the ladle, which is to be carefully introduced into the eprouvette, and pushed up to the end of the bore; the muzzle is then to be raised until the bore is about 45°, so as to let the charge fall to the bottom.

4. The gun being placed horizontally, and at rest, the index is brought by means of the screw to 0°; the gun is then fired by means of a quick match placed in the vent, and the arc of vibration noted in degrees and tenths. This being repeated not less than three times at stations at home, and five times at stations in Ireland and abroad, the result will be the average comparative strength, which should be nearly as follows:

	Charge.	
With new large-grained Service powder	2 oz. . . .	21°
With large-grained powder, issued, but returned into store, and considered serviceable	2 oz. . . .	20° 5′
With fine-grained powder, new	2 oz. . . .	26°
With fine-grained powder, returned into store . . .	2 oz. . . .	24°

5. In repeating the several rounds of proof, should the zero on the graduated arc not correspond with the index, as in No. 4, the gun is to be moved backward or forward until they do correspond; but the screw of the index is upon no account to be altered after the first round.

6. It is of much consequence to keep the bearing and other parts of the spindle clean and well oiled, so as to produce as uniform a friction as possible; it is, therefore desirable to make the gun swing for some minutes when in its place, and adjusted for firing, previous to the trial of the powder, that every part may find its proper bearing.

7. The gun ought to be fired immediately after being loaded.

8. The gun is to be regularly sponged after each round; and after every proof of the sample of powder, it is to be well washed out and dried before another sample is proved.

EQUIPMENT OF ARTILLERY.*

SECTION I.

"Trouver une organization d'unité d'Artillerie (c'est à dire de la batterie) qui renferme implicitement les formes qu'elle effecte dans la guerre de campagne, de montagne, de siége, la défence des places et des côtes."—*Anonymous, in 20th vol. of Journal des Sciences Militaires, 3rd Series.*

The British Artillery, whether for the Field, Garrisons, Sieges, or the Defence of

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* By Colonel Lewis, C.B., R.E.

Fortresses, or Coast Defences, is equipped by the Department under the Director-General of Artillery at Woolwich. (See Article 'Artillery,' Section II.)

The simplicity of the arrangement adapted since the Peace to the nature of our Service, the avoidance of all specialities, of a train of conductors and mechanics distinct from the artillerymen, is not understood by foreigners, nor is the composition of this Service generally known at home.

Captain Jacobi, of the Prussian Service, in his work on Artillery, states:

"It is difficult to understand the composition of batteries of English artillery, as all is uncertainty and confusion in that Service. There is no positive rule for fixing the number and nature of ordnance, or determine the supply and the composition of the parks and reserves; all is abandoned to the decision of the General-in-Chief commanding the expedition."

It is difficult to disabuse the minds of foreigners, and explain the working of the system adopted for the British artillery, so imperfectly understood in our own Service; hence some pains have been taken here to detail the equipments, and for this purpose Tables have been framed from authentic sources.

It has been before shewn that the *personnel* of the artillery comprises one regiment for the general organization of the whole; that Woolwich is the arsenal, head-quarters, and school of instruction; that the regiment is subdivided into battalions for administrative purposes, and those again into troops and companies; the latter, forming $\frac{7}{8}$ths of the whole force, is available either for the field, garrison, coast defences, or the attack of places.

The company or troop is therefore the Unit in the artillery that the battalion is to the infantry, or squadron to the cavalry; the number of companies or troops being increased or diminished for war or peace, or each may be expanded or contracted, whether for garrison or field duties.

The whole scope of instruction is therefore primarily given to perfect this unit, whose destiny is for either or many of the duties which may probably be assigned to it; and after leaving the head-quarters, or school of instruction, the Captain commanding endeavours to keep it perfect for any duties which circumstances may assign to it.

The distribution of the personnel, under the arrangement of the Deputy Adjutant-General of Artillery, depends upon the exigency of the service, but the period abroad is regulated to a certain number of years, so that the company (the horse artillery does not serve in the colonies) returns to head-quarters to be recruited, re-instructed, and made conversant with all the improvements which may have occurred in ten or twelve years.

Recurring to the subject *Equipment*, which may be said to be formed on the combination of the *Personnel* and *Materiel:* the question appears to have been well considered, in 1819, by a Committee of General and Field Officers of Artillery, who entered into the experience of the previous 25 years, and it is probable that their opinion will be the basis for all future artillery equipments, with trifling modifications. The following principles are founded on the opinions of that Committee, with some observations rather to explain the Tables of Equipment, and render the subject familiar to all branches of the Service.

The Article * 'Equipment of Artillery' is given under the following heads of *Field Artillery* and *Siege Artillery:* the equipments of artillery for the 'Defence of Fortresses' and 'Defence of Coasts' are explained under their respective heads, as neither of these questions was considered by the Committee, or any rule established for their equipments in our Service.

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* See Section II., paragraph 2, of Article 'Artillery.'

SECTION II.—FIELD ARTILLERY.

1. *Horse Artillery*, explained in Table I., gives the equipment of four descriptions of batteries for that Service: why the Committee took into consideration the probability of 12 or 9-pounder brass guns being adopted does not appear, and it gave no opinion upon the subject, further than remarking that they were not originally proposed when the horse artillery was constituted.

2. But as here suggested, on examining the Tables, it will be seen that, deviating from the original intentions, the heavy equipments lose the first essential of horse artillery, *mobility*, and its capability of acting with and supporting cavalry, besides diminishing in the application of 12 and 9-pounder guns the supply of ammunition from ⅓rd to ¼th,—a point of great importance to this force, as rapidity of firing and the consequent necessary supply is next to activity of movement. It is considered then, that the 6-pounder gun and 12-pounder howitzer should be preferred for the equipment of horse artillery.

3. The Peace Establishment of this force would appear to comprehend every thing that is necessary and adapted for an increase to that of War and active Service.

4. *Field Foot Artillery* may be said, as it now exists, to be in a state of transition, and expressly organized for a Peace Establishment. The Tables II. III. and IV. are, however, framed upon a supposed war equipment, as recommended by the Committee of Artillery Officers at the close of the last war.*

5. Table II. explains the equipment of four descriptions of foot artillery field batteries, from the 9-pounder brass to the 3-pounder (both inclusive) of 6 pieces to each battery, or 5 guns and 1 howitzer, which has been deemed the most convenient combination of men, horses, and ammunition, for that armament, as regards economy and management, and is especially adapted to the unit or company upon the War Establishment.

6. The most efficient battery for this force is unquestionably the 9-pounder with the 24-pounder howitzer, when the country permits the use of so heavy a field force; and as mobility is of secondary consideration with foot artillery, and as it is especially organized to act with infantry and support its movements, the *effect* of that artillery is the first essential.

7. Table III. is an equipment of reserve field batteries, or batteries of position, the first comprising 4 heavy pieces of iron, three 18-pounder guns, and one 8-inch howitzer: this force was organized in the latter campaigns of the Peninsular War for the attack of Posts, and if associated with the heavy field batteries would make a formidable siege equipment for the attack of Posts and *Places du moment*. The 12-pounder brass gun, with the lately introduced 32-pounder howitzer, form a powerful battery of reserve or position, and would at critical periods of actions be of great effect. The 9-pounder brass guns, and 24-pounder howitzers, batteries of reserve, are for *auxiliary* batteries, to be attached or posted to infantry for special purposes, in addition to those acting with the divisions, and forming part of their strength. One, two, or more of these 9-pounder batteries of reserve, placed in battery under favorable circumstances, would effect more than if divided over the field of battle, attached to particular bodies where their services might not be available from the nature of the ground, or too great distance from the important point; but if kept in hand until the decisive moment arrives, as at Waterloo, when 24 pieces were placed in battery to repel the final effort of the enemy and insure victory, it is then that reserve batteries are essential.

* With some slight modifications in the ammunition to suit present arrangements.—*Ed.*

8. Table IV. gives the equipment of very light field-pieces for Colonial and Mountain services: these batteries are insignificant in every way, and only fit to be employed in taking the field against savages or an insurgent force, when the *prestige* of artillery would have every necessary effect. Many circumstances may require their equipment in our Service; therefore their nature is explained in this Table. Mountain artillery, when the whole is carried on the backs of animals on pack-saddles, is extremely difficult of application, and *can only be successfully used in those 'Alpine' countries where the mule and muleteer are trained to this species of transport;* but if men, unaccustomed to mules and the animals to them, attempt to move with mountain artillery, a series of difficulties will arise, which can only be understood by those who have witnessed the operation.

Plates VIII. IX. XII. to XV., XIX. to XXX., of Article 'Carriage,' refer to field artillery equipments; and Tables C. F. of 'Artillery,' explain the nature of the ordnance, their weight, and ranges.

SECTION III.—SIEGE ARTILLERY.

Table V. is a detail of a battering train of 100 guns of heavy iron ordnance, in the proportion of guns $\frac{6}{10}$ths and howitzers and mortars $\frac{4}{10}$ths, with 40 small brass mortars. The ammunition provided is 1000 rounds for each 24-pounder gun; 1200 rounds for each 12-pounder gun; 10-inch and 8-inch shells; 600 rounds for each iron mortar and howitzer; and 200 rounds for each brass mortar: this supply is exclusive of case and carcasses. The number of men calculated for this siege equipment, as necessary to give three reliefs and laboratory duties, is 1344, or 15 companies of artillery; and the calculation is based upon the probability of $\frac{3}{4}$ths of the ordnance being brought into play at one time, as follows:

Detail of Three Reliefs.

	Non-commissioned Officers and Men.
Twenty-five 24-pounder guns, at 6 men each	150
Twenty 12-pounder guns, at 5 men each	100
Four 10-inch howitzers, at 6 men each	24
Sixteen 10-inch mortars and 8-inch howitzers, at 5 men each	80
Ten 8-inch mortars, at 4 men each	40
Total seventy-five pieces of ordnance requiring	394
	3
Total for three reliefs	1182
For laboratory duties	50
Military conductors	12
Reserve to replace casualties and bring up ammunition	100
Total	1344

In further explanation of Table V., reference is made to Article 'Artillery;' Plates VI. VII. VIII. IX. XVI. XVII. XXXII. and XXXIV. of Article 'Carriage;' from which some judgment may be formed of the immense equipment of carriages and ordnance necessary, as comprised in that Table, for a Siege Equipment of Artillery.

SECTION IV.

ABSTRACT OF A REPORT OF A COMMITTEE OF ARTILLERY OFFICERS ON FIELD ARTILLERY EQUIPMENTS, WITH REMARKS THEREON.

1. These remarks may be deemed an act of supererogation upon the opinions of distinguished persons whose experience embraced a period of fifty years, in the latter half of which field artillery may be said to have been created and perfected. The substance of the Report (which is printed in italics) is limited to such matter as may be considered instructive and useful to the Service generally.

2. *Composition of Field Batteries.—The equipment to be* 5 *guns and* 1 *howitzer for brass ordnance, and* 3 *guns and* 1 *howitzer for iron.*

3. As no explanation is given why this arrangement has been adopted as a principle, it may be remarked that it can be deviated from when circumstances recommend the change to 8 or 9 pieces for field foot artillery by augmenting the companies from 90 to 120 men, which the permanent complement of 5 Officers seems calculated to command. The horse artillery batteries may be limited to 6 pieces; but when the divisions of infantry are larger, and the country favors a larger proportion of artillery, the question may be whether the field foot batteries should not be in preference 8 pieces, comprising six 9-pounder guns and two 24-pounder howitzers, rather than give to each division two batteries of 6 each, and provide for the difference in batteries of reserve, as adverted to in Section II., paragraph 7.

The supposition of having howitzer batteries of reserve presents this difficulty, or rather objection, that they do not carry any round shot, and are therefore unequal to fulfil all the duties of reserve batteries or batteries of position.

4. *Number of Carriages and Rounds per Gun for Field Batteries.—The latter regulates the former, and the whole composed as follows:*

		Rounds each.	No. of Carriages.
Field Batteries.	*Batteries of* 18-*pr. guns and* 8-*in. howitzers*	*G 180 H 112	23
	” *of* 12-*pr. guns and* 5½-*in. howitzers*	G 184 H 144	23
	” *of* 9-*pr. guns and* 5½-*in. howitzers*	G 166 H 144	19
	” *of* 6-*pr. heavy guns and* 5½-*in. howitzers*	G 230 H 144	19
	” *of* 6-*pr. light guns and* 4⅖-*in. howitzers*	G 223 H 236	18
	” *of* 3-*pr. heavy guns and* 4⅖-*in. howitzers*	G 316 H 236	17
Colonial ”	*of* 3-*pr. light guns and* 4⅖-*in. howitzers*	G 154 H 80	12
Mountain ”	*of* 3-*pr. light guns and* 4⅖-*in. howitzers*	G 116 H 72	4

In addition to the above, it was proposed that a supply for a six months' consumption should be at least four times the above.

5. The arrangement and distribution of ammunition is principally departmental, and exceeds the purposes of this work.

* G, Gun; H, Howitzer.

6. *Horsing field batteries for foreign service was regulated upon the principle of providing for every*

18-pounder gun and 8-inch howitzer	10 *horses.**
12, 9, and heavy 6-pounder gun, and 24-pounder howitzer .	8 ,,
Light 6-pounder, heavy 3-pounder gun, and 12-pr. howitzer	6 ,,
All four-wheeled carriages belonging to field batteries . .	6 ,,

The reasons given for adopting this arrangement were, that entering on a campaign will not be the guide for horsing batteries, with good roads, stables, and forage; but when the animals are exposed, traversing bad roads with a precarious supply of forage will form the principles to regulate the number, and that by rather over horsing the lighter carriages attached to each battery, the animals of the gun and ammunition carriages will be kept effective, and the Officer in command prevented the necessity of requiring aid from the infantry, and the artillery movements kept from interfering in obstructing the former.

7. The only observation offered is to draw attention of the General Officers and Staff Officers to the vast supply necessary to a field battery,—of importance in the accommodation and provision for forage.

8. *Drivers.—The Committee assumed the principle that one Company of Artillery, consisting of 5 Officers, 1 company serjeant, 2 other serjeants, 3 corporals, 6 bombardiers, 2 drummers, and 90 gunners,† was not more than adequate to the service of a 9-pounder battery, being that in most general use; and as the 12-pounder battery will require a little more, and the light 6-pounder battery may be worked with a less proportion, they adhered to the principle of a company per battery; and that the artillery drivers must be kept distinct, as they are liable to separation in emergencies of service; and that therefore the equipment of a field battery will take a few more non-commissioned officers and soldiers than it might require if formed into one body constantly acting together, as in the Service of the Continental Powers, and in our Royal Horse Artillery.*

9. Notwithstanding the opinion thus given upon the previous practical working of a Field Foot Artillery in the British Service, it may be remarked that this arrangement has been subverted, and the present organization of a Company of Artillery is of 'Gunner' and 'Driver,' in which the men are capable of acting in either capacity. This change was probably threefold: 1st, to disembody a defectively organized force; 2nd, experimentally; and 3rd, as a Peace Establishment. It is considered, however, that in the event of a war, a Corps of Drivers, or Field Train, must be re-organized, as a necessary and a useful adjunct to the Artillery; for the former body, the Corps of Drivers, was brave and effective, considering the duty of a driver is more passive than active, and hence requires a greater proportion of determination. Probably in the re-organization of a Corps of Drivers, the Officers of the Royal Artillery would be

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* The Duke of Wellington appeared averse to this very large demand of horses, as inconsistent with the means of almost any country; and latterly, in the French Service, six is the maximum number of horses allowed to Field Artillery, even for 12-pounders and 6-inch howitzers, upon the principle that rapidity of movement cannot in any case be required for those pieces, and that the men should be always on foot.

† The strength at present (1st April, 1846) is,

5	Officers,
1	Colour-Serjeant,
3	Serjeants,
3	Corporals,
4	Bombardiers,
85	Gunners and Drivers,
2	Drummers and Trumpeters.
Total . . 103	

attached to them, in a manner similar that the Companies of Sappers are officered by the Engineers in our Service; and thus, whether a Driver Officer or Artillery Officer, or by whatever appellation he may be termed, he would take his place in the command of the battery according to his rank. It must be obvious to every one practically acquainted with the Artillery Service that the efficient foot artilleryman or gunner must be disqualified in many respects for a driver; that the one should be tall and powerful, and the other short and compact; and in the enlistment of a large force for a War Establishment, the consideration of being able to recruit from that standard of height sufficient for a driver, whose destiny is exclusively for a field train, is of great importance.

10. *Arms of Artillerymen and Drivers.—The Committee recommend a better description of sword, and that the drivers should be armed.*

11. This is a subject delicate to touch upon, as the Artillery evince a particular dislike to have their batteries encumbered with small arms; nevertheless it is suggested that the carbine should be the arm of the gunner, even with the field batteries; and the facility with which it might be slung on the waggon removes the principal objection. The importance of being able to clear or feel the way in the movements of a battery without the assistance of infantry, and if attacked by light cavalry, of having the means of intrenching themselves among their waggons, seem strong reasons for adopting the carbine as an arm for foot artillery under all circumstances. It appears as consistent as furnishing the horse artillery with cavalry appointments, as to the propriety of which there has been no question.

SECTION V.

ABSTRACT OF OBSERVATIONS WITH REGARD TO THE EQUIPMENT OF A BATTERING TRAIN.

1. *Ordnance.—The proportion fixed on is* 6 *guns to* 4 *heavy mortars and howitzers, which, in the consideration of the Committee, may in general be adhered to with propriety; and they are borne out in this opinion by our principal armaments during the late war, as well as by the more modern French details for equipping Battering Trains.*

2. In the Article 'Artillery' of this work, Section V., it has been shewn that in a recent ordinance of the French Army, one-half of a siege equipment is composed of heavy mortars and howitzers.

3. *The Committee likewise recommend, that with every battering equipment there should be a portion of small mortars and howitzers, in the proportion of at least one-third, and their calibre should correspond with the heavy artillery employed.*

4. This affords an opportunity of again suggesting the introduction of the $6\frac{1}{5}$ brass mortars to correspond with the howitzer lately introduced, and disuse of the $4\frac{2}{5}$, as likewise of the adoption of a pierrier, or stone mortar, of light construction, that can easily be transported to the third parallel, or demi-parallel, and capable of pitching heavy shells a short distance and throwing 1-℔. balls.

5. *The Committee proposed to employ with battering trains iron* 12-*pounders eight and a half feet long, in the proportion of one-third the number of guns, being, it was conceived, sufficiently powerful for direct fire to dismount the enemy's artillery, as well as for firing en ricochet; and the diminished weight of ammunition is an important advantage attending the employment of this nature, but it is an arrangement that can be admitted only in cases where there is an adequate number of* 24-*pounders; and it would therefore be better with small equipments that all the guns should be of the heavy calibre.*

6. Table V., which accompanied the Report of the Committee, gives one-half 12-pounder guns: however, as the Duke of Wellington was not convinced by the reasoning of the Committee, it may be presumed that that piece will not in future form part of a battering equipment; and the economy in ammunition is questionable, from the inferior effect to the 24-pounder gun or 8-inch howitzer, one round of either of the latter being equal to three of the 12-pounder gun.

7. *This equipment has been made on a supposition of the new iron* 10-*inch and* 8-*inch howitzers being introduced into the Service in preference to brass, the latter being generally injured by their own fire.*

8. In the assumed equipment for a battering train, in the Article 'Artillery,' the 8-inch iron howitzer is recommended in the proportion to guns as 4 is to 6, and the whole to consist of 30 pieces of heavy iron ordnance, and 10 light brass, in order to simplify the armament, and render the formation of equipments more easily adapted to the probable wants of the Service; and instead of that proposed in Table V., to adopt 15 twenty-four pounder guns,
10 eight-inch howitzers, } Iron.
5 ten-inch mortars,

30 total heavy ordnance.

5 $6\frac{1}{5}$ mortars, } Brass.
5 $5\frac{1}{2}$ do.

10 total light ordnance.

And multiply this as a single unit (or proportion) of 30 heavy pieces for the attack of larger or more considerable fortresses.

9. *Ammunition.—In arranging the proportions of ammunition for all battering equipments, it would be a good principle to establish that they should be of three descriptions.*

	Rounds per gun.
Large, for the siege of a fortress of the first class	1500
Medium, for those of the second class	1000
Small, for the attack of a place or post but slightly fortified, and not requiring a regular attack	500

In reference to this arrangement, it ought to be considered as a fixed principle of equipment in all cases, that the proportion of ammunition required should be of round shot and shells to the full demanded, independent of the requisite quantity of case, spherical case, carcasses, &c. The powder is calculated at the following rates.

For Guns.—The Service charges for the whole number of rounds, including case-shot and spherical case.

10-*inch howitzers and mortars*,	7 lbs. *each round*,	*including*	*powder*	*for filling.*
8-*inch howitzers*	6 lbs.	"	"	"
8-*inch mortars*	4 lbs.	"	"	"
$5\frac{1}{2}$-*inch mortars*	$1\frac{1}{2}$ lb.	"	"	"
$4\frac{2}{5}$-*inch mortars*	1 lb.	"	"	"

10. The proposition for the supply of ammunition, stores, &c., &c., by the Committee may be considered as a departmental question, so that any observation here would be superfluous; and as they are classed in Table V. by the Committee, so as to afford a facility of reference, the quantities may be given for that or the equipment as proposed of 30 heavy pieces, and the necessary articles demanded in the latter proportion. The great utility of the Table lies in the enumeration of the vast quantity and description of articles requisite for a siege, which few Officers could provide for without its assistance.

CONCLUDING REMARKS.

Adverting to the original proposition,—that the true unit for the Equipment of the Artillery is the Company,—it is conceived that this has been established in a satisfactory relation to the several duties of this regiment,—whether for field batteries or for garrison duties, defence of places, defence of coasts, or for sieges,—as the transition from one to the other is rendered easy by such an arrangement; and thus the homogeneous character of this Service is preserved: otherwise, special Corps of Artillery must be organized for special duties, which would impair the *general* efficiency of every branch, taking into consideration the necessary employment of a large portion on foreign and colonial duty.

And in the event of a *field train** of non-commissioned Officers and Drivers being re-organized, the course of instruction in the manége at Woolwich renders the Officers of Artillery fit to command that force when sent to field duties,—the driver corps, like the horses and equipage, being adjuncts to the Company when thus employed, it being evident that the battery is assigned to the Company, and not the Company to the battery,—a distinction that would appear trivial were the different services of the Artillery *special;* but they are not, and the elements are so various, and liable to frequent and sudden changes, that it is of consequence to preserve the perfection of the unit, which at such brief notice may be transferred from a Peace to a War Establishment,—from attack to defence of places, or from garrison to field duties. The object should be to complete the COMPANY as the MODULUS of this Service,—this important branch of a well-equipped army.

The 'Equipment of Rocket Artillery' † is postponed for want of authentic informa-

* The re-organization of a field train seems indispensable, not for batteries alone, but for the multifarious duties which will occur in the movement of ammunition, heavy artillery, pontoon trains, and other equipments essential in taking the field.

† WAR ROCKETS, AS ARTILLERY.

Extracts from 'THE SPIRIT OF MILITARY INSTITUTIONS,' *by* MARSHAL MARMONT, DUKE OF RAGUSA, *the celebrated Aide-de-Camp of* NAPOLEON.—*Chapter* III., *Artillery.*

"The third arm indispensable in war is artillery. Of paramount importance, its efficiency depends on organization, and on the principles on which it is based. * * * In war, artillery has daily been acquiring more importance, not only on account of its augmentation, but also from its increased facility of movement, which enables it to combine its operations *ad infinitum.* But to this power of rapid concentration there is a limit. Not only is the number of guns brought into the field circumscribed in its application by the expense it incurs,—but the embarrassment which the great excess of materiel occasions on the march would far exceed any advantage that could be derived from it in action. Experience has demonstrated that the maximum of artillery should be four guns to every thousand men. * * * But Congreve rockets, which have been so successively improved, and which are now directed with much accuracy, form at the present day an artillery that, by the development of which it is susceptible, may become the first arm.

"In fact, when an arm is only composed of projectiles, requiring the auxiliary aid of no machine to project them, and shewing no front to the fire of the enemy's artillery—when by the most simple dispositions such a momentary development can be given to their fire, that the entire front of a regiment is deluged with a shower of balls equal to the fire of a battery of 100 guns—then so powerful will be found these means of destruction that it will be impossible to guard against them by a continued adherence to the existing principles of war. The following is, in my opinion, the manner in which Congreve rockets should be employed. In every regiment, 500 or 600 men should be drilled to the service of this new arm. One or two light waggons would suffice to transport 100 tubes or rests, such as the Austrians have adopted—each of which, served by three or four men, would at command deploy a line of fire which the imagination can scarcely conceive. To such a fire would it be possible to oppose troops *en masse*, or even deployed in several parallel lines? Most assuredly not! But the gain of a battle consists in obliging the enemy to retire: for that purpose he must be attacked, the intervening space between the two armies must be traversed—and to accomplish this with the least possible loss, the arm which possesses the greatest rapidity of action ought in preference to be employed. This duty must, therefore, devolve on cavalry, but it must be trained to a new system

tion, and which may be occasioned by the neophyte state of that arm of the Artillery. Already the rocket carriage, given in Plate XXXI. of 'Carriage,' has become obsolete.

of manœuvres, to enable it to face the enemy's fire with the fewest chances of destruction. It should, therefore, be thrown forward in skirmishing order, but prepared to rapidly concentrate and charge at a moment's notice. The part which infantry enacts is here inverted; it becomes but the auxiliary of the rockets, or rather the latter become its arm *par excellence* while the firelocks dwindle down to mere accessories for the purpose of repelling an attack.

"Under this new system the instruction of infantry will be entirely different, and must be divided into two parts—the first, told off for the service of the rockets; the second, to support or act as a rallying point to the former when in immediate contact with the enemy. The proportion of arms as it now exists will undergo a change. More cavalry and less infantry will be required—the former drilled in a special manner. There will be also required, if I may be permitted to use the expression, an *infantry-artillery* for the rocket service, destined for the occupation of intrenched posts, the defence of fortresses, and the operations of mountain warfare.* But these projectiles acquire a vast importance under a thousand circumstances where guns are perfectly useless. In the mountains it is with the greatest difficulty that a small number of light guns, which produce but inconsiderable effect, can be transported. But the rocket combines extended range with multiplied fire. It may be established every where, on the crests of the highest peaks or on the lower plateaux of mountains. In the plains it converts every house into a fortress, and the roof of a village church is rendered at will the platform of a formidable battery. In one word, this invention, such as it now exists, and susceptible as it still is of further elaboration, adapts itself to every variety of circumstance, to every possible combination, and must exercise an immense influence on the destinies of armies.

"If, however, Congreve rockets are served by a special corps, if they are considered purely in the light of artillery, they will be so circumscribed in number, that their effect would be inconsiderable. It is by giving to them an immense development that their extraordinary powers can alone be brought into their fullest operation, and for that purpose they must be made the general arm of an army. Man reflects but little on the nature of things. He is governed by the opinions and decisions of others, moves in a vicious circle of monotonous uniformity, without ever exercising his intelligence on the work of alteration or improvement. Thus it will be long before the power of Congreve rockets will be felt and appreciated. But if, on the outbreak of the first war, a General of distinguished ability views the question in all its bearings—embraces all the consequences that may be derived from it—if he prepares in silence his means to deploy them on the first field of battle, his success will be such that, until the enemy shall employ the same, he will prove irresistible. At the moment of making this grand experiment, the genius of the General-in-Chief will exercise a great ascendancy on the fate of the war.

"But although the calculations of reason and foresight all appear to justify the results I have foretold, still experience alone can incontestably establish the merit of this new invention. There are so many unforeseen events which modify the most prudential foresight, the most seductive prospects, that a man of sense and prudence will not be thoroughly convinced until facts have, in the most absolute manner, realized his hopes. Nevertheless, I must repeat that the probability is so strong, and presents itself in so conclusive a shape, that a skilful General ought, on the outbreak of the first war, to prepare for the employment of this new weapon in the way I have explained, disconcert and astonish his adversary by its effects. If he alone makes use of it, in all probability he will remain master of the field. If, on the other hand, the enemy should have displayed equal prudence and foresight, he will escape the certainty of becoming his victim. But this vigilance and forethought ought beforehand to embrace not only the immediate employment of this new means, but also all the consequences that may result from it, relatively to the other arms, to their proportions, their manœuvres, and their employments. It is evident that, after the first successful application of the Congreve rocket in a campaign, it will be adopted in all the armies of Europe. An equilibrium will be then established—all exclusive advantage set aside. But the art of war will undergo a singular modification, the moral effect of battles will be greater, their action more decided, and the effusion of blood will be consequently less. For in war it is not the number of men who are killed, but the number who are terrified, which is the guarantee of victory. I, therefore, again repeat, that Congreve rockets will produce a revolution in the art of war. They will redound to the glory and profit of the General who will the first comprehend their importance, and skilfully avail himself of all the advantages to be derived from them."

* More especially in Canada, where the numerous rivers and lakes render the movements of Artillery always difficult, and at times impossible. The carcass-rocket seems particularly applicable to the destruction of blockhouses on isolated points, rendered inaccessible to guns by the surrounding forests, swamps, &c., of an unreclaimed country.—*Ed.*

TABLE I.

Equipment of Royal Horse Artillery Batteries for Service, for either of the following Brass Ordnance.

Nature of Equipment.	12-pr. Gun and 24-pr. Howitzer Battery.			9-pr. Gun and 24-pr. Howitzer Battery.			Light 6-pr. Gun and 12-pr. Howitzer Battery.			Heavy 3-pr. Gun and 12-pr. Howitzer Battery.			Remarks.
	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	
Ordnance.													See Artillery Plates I. & II., and Artillery Tables D. E. and F.
Guns	5		5	5		5	5		5	5		5	
Howitzers		1	1		1	1		1	1		1	1	
Total pieces of Ordnance			6			6			6			6	
Establishment.													
Captains			2			2			2			2	
Subalterns			3			3			3			3	
Staff Serjeants			2			2			2			2	
Serjeants			3			3			3			3	
Corporals			3			3			3			3	
Bombardiers			8			7			6			6	
Gunners	10	10	96	9	9	90	8	8	80	8	8	80	
Trumpeter			1			1			1			1	
Farrier			1			1			1			1	
Carriage Smith			1			1			1			1	
Shoeing „			5			4			3			3	
Collar-makers			2			2			2			2	
Wheelers			2			2			1			1	
Drivers, Serjeant			1			1			1			1	
„ Corporals			4			4			3			3	
„ Privates			93			80			69			65	
Medical Officer			1			1			1			1	
Total Establishment			228			207			182			178	
Carriages.													See Plates XIV. XV. XIX. to XXIV. XXVII. XXVIII. XXXV. and XXXVI. of Article 'Carriage.'
Gun and Howitzer carriages	5	1	6	5	1	6	5	1	6	5	1	6	
Gun and Howitzer spare do.	1		1	1		1	1		1	1		1	
Store waggons			2			1			1			1	
„ cart			1			1			1			1	
Forge waggon			1			1			1			1	
Ammunition waggons	10	2	12	7	2	9	6	2	8	5	2	7	
Total Carriages			23			19			18			17	
Horses.													This includes spare horses at $\frac{1}{10}$ per battery.
Riding			79			78			64			64	
Draught	10	10	160	8	8	135	6	6	115	6	6	108	
Baggage			7			7			7			7	
Total Horses			246			220			186			179	
Ammunition.													
Round	120		600	$121\frac{3}{5}$		608	$172\frac{2}{5}$		863	272		1360	
Case	14	12	82	$19\frac{1}{5}$	12	108	21	12	117	44	12	232	
Spherical do.	50	72	322	$25\frac{3}{5}$	72	200	30	118	268		118	118	
Shells		56	56		56	56		98	98		98	98	
Carcasses		4	4		4	4		8	8		8	8	
Total Ammunition			1064			976			1354			1816	

TABLE II.

Equipment of Field Batteries of Royal Foot Artillery for Service, for either of the following Brass Ordnance.

Nature of Equipment.	9-pr. Gun and 24-pr. Howitzer Battery. Gun.	Howitzer.	Total.	Heavy 6-pr. Gun and 24-pr. Howitzer Battery. Gun.	Howitzer.	Total.	Light 6-pr. Gun and 12-pr. Howitzer Battery. Gun.	Howitzer.	Total.	Heavy 3-pr. Gun and 12-pr. Howitzer Battery. Gun.	Howitzer.	Total.	Remarks.
Ordnance.													See Artillery Plates I. & II., and Artillery Tables D. E. and F.
Guns	5		5	5		5	5		5	5		5	
Howitzers . . .		1	1			1		1	1		1	1	
Total pieces of Ordnance			6			6			6			6	
Establishment.													Two men are carried on the gun limbers, and six men on each ammunition waggon. See Plates XXVII. and XXVIII. of Article 'Carriage.'
Captains			2			2			2			2	
Subalterns . . .			3			3			3			3	
Serjeants			3			3			3			3	
Corporals . . .			3			3			3			3	
Bombardiers . .			6			6			6			6	
Buglers			2			2			2			2	
Gunners			90			90			80			80	
Drivers, Lieutenant			1			1			1			1	
,, Staff Serjeant			1			1			1			1	
,, Serjeants . .			2			2			2			2	
,, Corporals .			5			5			4			4	
,, Bugler . .			1			1			1			1	
,, Farrier . .			1			1			1			1	
,, Shoeing Smiths			4			4			3			3	
,, Carriage do.			1			1			1			1	
,, Collar-makers			2			2			2			2	
,, Wheelers . .			1			1			2			2	
,, Privates . .			84			81			73			70	
Medical Officer . .			1			1			1			1	
Total Establishment			213			210			191			188	
Carriages.													See Plates XIV. XV. XXI. to XXIV. XXVII. XXVIII. XXXV. and XXXVI. of Article 'Carriage.'
Gun and Howitzer carriages	5	1	6	5	1	6	5	1	6	5	1	6	
Gun and Howitzer spare do.	1		1			1			1	1		1	
Store waggon . .			1			1			1			1	
,, cart . . .			1			1			1			1	
Forge waggon . .			1			1			1			1	
Ammunition do. .	7	2	9	6	2	8	6	2	8	5	2	7	
Total Carriages			19			18			18			17	
Horses.													This includes spare horses at $\frac{1}{10}$ per battery.
Riding			19			19			18			18	
Draught			137			131			117			111	
Baggage			8			8			8			8	
Total Horses			164			158			143			137	
Ammunition.													
Round	$121\frac{3}{5}$		608	174		870	$172\frac{3}{5}$		863	272		1360	
Case	$19\frac{1}{5}$	12	108	22	12	122	21	12	117	44	12	232	
Spherical do. . .	$25\frac{3}{5}$	72	200	34	72	242	30	118	268		118	118	
Shells		56	56		56	56		98	98		98	98	
Carcasses		4	4		4	4		8	8		8	8	
Total Ammunition			976			1294			1354			1816	

TABLE III.

Equipment of Reserve *Field Batteries of Royal Foot Artillery, for either of the following pieces.*

Nature of Equipment.	Iron. 18-pr. Gun and 8-pr. Howitzer Battery.			Brass. 12-pr. Gun and 32-pr. Howitzer* Battery.			Brass. 9-pr. Gun and 24-pr. Howitzer Battery.			Remarks.
	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	
Ordnance.										See Artillery Plates I. & II., and Artillery Tables D. E. and F.
Guns	3		3	5		5	5		5	
Howitzers		1	1		1	1		1	1	
Total pieces of Ordnance			4			6			6	
Establishment.										
Captains			2			2			2	
Subalterns			3			3			3	
Serjeants			3			3			3	
Corporals			3			3			3	
Bombardiers . . .			6			6			6	
Buglers			2			2			2	Three men are carried on the gun limber of the 12-pr. gun, two on the 9-pr., and with the 18-pr. iron 18 howitzer all are on foot.
Gunners			90			90			90	
Drivers, Lieutenant .			1			1			1	
,, Staff Serjeant .			1			1			1	
,, Serjeants . .			2			2			2	
,, Corporals . .			6			6			5	
,, Bugler . . .			1			1			1	
,, Farrier . . .			1			1			1	
,, Shoeing Smiths			4			4			4	
,, Carriage do. .			1			1			1	
,, Collar-makers .			2			2			2	
,, Wheelers . .			2			2			1	
,, Privates . . .			102			99			84	
Medical Officer . .			1			1			1	
Total Establishment			233			230			213	
Carriages.										See Plates VIII. to XIV. XVIII. XIX. XXVII. XXVIII. XXXV. and XXXVI. of Article 'Carriage.'
Gun and Howitzer { carriages .	3	1	4	5	1	6	5	1	6	
Gun and Howitzer { spare do. .	1		1	1		1	1		1	
Store waggons . . .			2			2			1	
,, cart			1			1			1	
Forge waggon . . .			1			1			1	
Platform do. . . .			1							
Ammunition do. . .	9	4	13	10	2	12	7	2	9	
Total Carriages			23			23			19	
Horses.										
Riding			20			20			19	This includes spare horses at $\frac{1}{10}$ per battery.
Draught			170			164			137	
Baggage			8			8			8	
Total Horses			198			192			164	
Ammunition.										
Round	132		396	120	*	600*	$121\frac{3}{5}$		608	See Tables of Article 'Ammunition' in respect to packing.
Case	12	12	48	14			$19\frac{1}{5}$	12	108	
Spherical do. . . .	36	52	160	50			$25\frac{3}{5}$	72	200	
Shells		48	48					56	56	
Carcasses								4	4	
Total Ammunition			652						976	

* Arrangements not as yet made for 32-pounder howitzer.

TABLE IV.

Equipment of Light Field Batteries for Colonial *and* Mountain *Service.*

Nature of Equipment.	Colonial Service.							Mountain Service.						
	3-pr. Gun and Coehorn Howitzer on single draught.			1-pr. Gun and Coehorn Howitzer on single draught.			Remarks.	3-pr. Gun and Coehorn Howitzer or Pack Saddles.			3-pr. Gun and Coehorn Howitzer on single draught.			Remarks.
	Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.		Gun.	Howitzer.	Total.	Gun.	Howitzer.	Total.	
Ordnance.							See Table I. Article 'Artillery.'							See Table I. Article 'Artillery.'
Guns	3		3	3		3		3		3	3		3	
Howitzer		1	1		1	1			1	1		1	1	
Total pieces of Ordnance			4			4				4			4	
Establishment.							All dismounted except the Officer.							All dismounted except the Officer.
Lieutenant			1			1				1			1	
Non-com^{d}. Officers			4			4				5			5	
Gunners			20			20				25			21	
Drivers, Corporal			1			1				2			2	
„ Shoeing Smith			1			1				1			1	
„ Privates			14			11				20			19	
Total Establishment			41			38				54			49	
Carriages.							See Table I. Article 'Artillery,' and Plate XXX. Article 'Carriage.'							The guns and howitzer only on draught.
Single draught											3		3	
Gun	3		3	3		3						1	1	
Howitzer		1	1		1	1								
Ammunition carts	6	2	8	3	2	5								
Total Carriages			12			9							4	
Horses or Mules.														The ammunition and stores carried on packs.
Riding			1			1				4			4	
Draught			26			20							4	
Pack										30			25	
Baggage										1			1	
Total Horses or Mules.			27			21				35			34	
Ammunition.														
Round	125		375	150		450		72		216	96		288	
Case	29	12	99	15	12	57		12	12	48	20	16	76	
Shells		68	68		68	68			48	48		56	56	
Total Ammunition			542			575				312			420	

TABLE V.

Detail of Battering Train of 100 *Pieces of Heavy Ordnance.*

The 24-pounders at 1000 rounds per gun, The 12-pounders at 1200 rounds per gun } exclusive of case and spherical.

The 10 and 8-inch shells at 600 per mortar and howitzer, The $5\frac{1}{2}$ and $4\frac{2}{5}$-inch do. at 200 per do. do. } exclusive of case and carcasses.

Ordnance and Implements.	Guns.		Howitzers.		Mortars.				
	24-pr.	12-pr.	10-in.	8-in.	10-in.	8-in.	$5\frac{1}{2}$ in.	$4\frac{2}{5}$ in.	
Ordnance, brass	,,	,,	,,	,,	,,	,,	20	20	Equal number with the large mortars and howitzers. One-half of each nature of small mortars.
Ordnance, iron	40	20	5	10	10	15	,,	,,	In proportion of 6 guns and 4 mortars and howitzers.
Carriages, complete, travelling with limbers	40	20	5	10	,,	,,	,,	,,	
Mortar beds and coins, wood	,,	,,	,,	,,	,,	,,	20	20	
Mortar beds and coins, iron	,,	,,	,,	,,	10	15	,,	,,	
Handspikes, traversing	,,	20	,,	10	,,	,,	,,	,,	
Handspikes, common	160	40	20	20	40	30	,,	,,	Heavy pieces at 4 each, light ditto at 2 each.
Hand crow-levers, 6 feet	40	20	5	,,	10	,,	,,	,,	
Iron crows, $5\frac{1}{2}$ feet	4	2	1	1	1	1	,,	,,	One for every 10 pieces of ordnance.
Sponges with staves, Rammers and bags	80	40	10	20	10	15	20	20	
Wadhooks with staves	10	5	,,	,,	,,	,,	,,	,,	One for every 4 guns.
Ladles with ditto	10	5	,,	,,	,,	,,	,,	,,	One for every 4 guns.
Jacks, hand-screw, large	10	5	2	3	,,	,,	,,	,,	One for every 4 guns and howitzers.
Grease boxes	40	20	5	10	,,	,,	,,	,,	
Lintstocks with cocks	40	20	5	10	10	15	20	20	
Claw hammers	40	20	5	10	10	15	,,	,,	
Punches for vents	80	40	10	20	20	30	40	40	
Priming irons, long, sets	40	20	5	10	10	15	20	20	
Portfire clippers, pairs	20	10	3	5	5	8	10	10	One to 2 pieces.
Powder horns, new pattern	40	20	5	10	10	15	20	20	
Gun locks*	44	22	6	11	,,	,,	,,	,,	One for every gun and howitzer, and $\frac{1}{10}$ spare.
Musket flints*	Two thousand,								or about 25 flints per lock.

* In these and other instances, throughout, the detonating principle would now be followed to a great extent; but this Table is given exactly as in the original.

TABLE V.—*Continued.*

GENERAL STORES.			No.	
Triangle gyns	Common		8	About 1 for every 12 pieces.
Iron blocks with brass sheaves	Treble		,,	Complete for 8 gyns.
	Double		,,	
White rope, fathoms	6-inch for slings		,,	
	4-inch for falls		,,	
Crab capstan	Complete		2	1 for 50 pieces.
Purchase block with brass sheaves	Treble		5	1 for 20 pieces.
	Double		5	
	Single		5	
Tarred rope	Coils	$4\frac{1}{2}$-inch	4	1 for 25 pieces.
Blocks	Double	10 ,,	8	Equal to number of gyns.
		8 ,,	8	
	Single	10 ,,	8	
		8 ,,	8	
		$5\frac{1}{2}$,,	8	
Rope, coils	Tarred	4 ,,	4	1 for 25 pieces.
		3 ,,	5	1 for 20 pieces.
		2 ,,	5	1 for 20 pieces.
		1 ,,	10	1 for 10 pieces.
	White	6 ,,	1	
		4 ,,	1	
		3 ,,	1	
		2 ,,	1	
Spun yarn	Coils		5	1 for 20 pieces.
Ratline	Do.		5	1 for 20 pieces.
Iron and Steel — Iron of sorts	Tons		2	1 ton for 50 pieces.
Iron and Steel — Steel, cwt.	Sheer		1	$\frac{1}{2}$ of each for 50 pieces.
	Blister		1	
Coals	Chaldrons		5	A chaldron for 20 pieces.
Candles	Cwt.		1	
Grease	Kegs		200	2 per piece.
Lanthorns	Muscovy		10	1 for 10 pieces.
	Tin		20	1 for 5 pieces.
	Dark		20	
For securing of powder	Tanned hides		50	1 for 5 pieces.
	Wadmilltilts		50	
	Hair cloths		100	1 per piece.
	Tar-paulins	30 ft. by 15	25	1 for 4 pieces.
		20 ,, 16	25	
		14 ,, 10	100	1 per piece.
Horse-shoes with 3 sets of nails each				3 sets of shoes for every single horse harness.
Shoeing tools				1 set for every 50 ditto.
Park pickets				1 for 5 single horse harness.
Wood mauls				1 for 10 pickets.
Nose-bags, new pattern				3 for every 2 horses' harness.
Corn sacks				1 for 4 ditto.
Forage cords, sets				1 for 2 ditto.
Additional head collars				1 in 5 of No. of single sets of harness.
Tools.				
Chests of Tools. — Collar-makers'			4	1 for 25 pieces.
Chests of Tools. — Wheelers'			8	1 for 12 do.
Chests of Tools. — Smiths'			4	1 for 25 do.
Chests of Tools. — Coopers'			2	1 for 50 do., if barrels are used.
Heavy sledge hammers			4	For knocking off trunnions.
Wrench hammers, of sizes			10	1 for 10 pieces.

TABLE V.—*Continued.*

GENERAL STORES.			No.	
Intrenching Tools.	Axes	Felling	50	1 for 2 pieces.
		Pick	100	1 for each piece.
	Spades		100	1 for each piece.
	Shovels		100	
	Hand	Bills	100	
		Hatchets	100	
	Barrows	Hand	50	1 for 2 pieces.
		Wheel	50	
	Grind-stones with trough		2	1 for 50 pieces.
	Helves for	Spades	50	Half in spare.
		Shovels	50	
		Felling-axes	25	
		Pick-axes	50	
	Pit saws		2	
	Cross-cut saws		2	
	Hand saws		10	1 for 10 pieces.
	Setters for saws	Pit	2	
		Cross-cut	2	
		Hand	2	
	Files for saws, dozens	Pit	2	
		Cross-cut	2	
		Hand	3	
Nails	Clasp	40-penny	3000	30 of sorts, per piece.
		30 „	2000	20
		20 „	4000	40
		10 „	4000	40
		6 „	2000	20
	Streak, of sorts		3000	30
Marline spikes			4	
Screws, of sorts, gross			10	1 gross for 10 pieces.
Glue, ℔s.			10	1 ℔. for 10 pieces.
Oaken skidding, 6 × 8 *running*			80	Feet.
Oak plank, 3-inch ends			„	
Plank, superficial feet	Elm	1-inch	50	
		$\frac{3}{4}$ „	50	
	Ash	$1\frac{1}{2}$ „	„	
		1 „	„	
Deals	Sawed		25	1 in 4 pieces.
	Whole		25	
Iron shot guages, sets			4	
Brass callipers, large, pairs			2	
Grates for heating shot			3	1 for 20 guns.
Fire irons for ditto, sets			„	In proportion to the grates.
Shot bearers				
Spare. Wheels	24-pounder	Gun	8	One spare wheel in 10 for gun and howitzer wheels, 1 spare wheel in 20 for gun and howitzer limbers, and the wheels of all other carriages.
		Limber	4	
	12-pounder	Gun	4	
		Limber	2	
	10-inch	Howitzer	1	
		Limber	„	
	8-inch	Howitzer	2	
		Limber	1	
	Waggons, Flanders pattern	Fore	10	
		Hind	10	
	Waggons, Forge		2	
	Platform carriage	Fore	3	
		Hind	3	
	Sling cart		2	
	Hand cart		5	
	Trench cart		5	

TABLE V.—*Continued.*

GENERAL STORES.		No.		
Axletrees.—Iron, whole	24-pounder	5	1 in 10 of ordnance	With beds of wood in proportion.
	10-inch howitzer	5		
	12-pounder	3		
	8-inch howitzer	3		
Axletree arms.—Iron, of sorts		35	1 in 10 of carriages	
Common handspikes		300	3 spare per piece.	
Traversing ditto		15	1 for two 12-pounders and 8-inch howitzers.	
Bail hoops		200	2 for each Flanders pattern waggon.	
In the rough.				
Spokes, of sorts		,,	In quantity equal to spare wheels.	
Felloes				
Shafts, of sorts		70	1 in 5 of the number of carriages.	
Splinter-bars, of sorts		25	1 in 10 of all 4-wheel carriages.	
Guides	Fore	12	1 in 20 of all 4-wheel carriages.	
	Hind	12		
Under-poles		10	1 in 10 for Flanders pattern waggon.	
Naves		10		
Tail-pieces		10		
Sweep-bars		10		
Shaft-bars, of sorts		25	1 in 10 of 4-wheel carriages.	
Iron tire		,,	Equal ¼th the material for repairing wheels.	
Camp equipage *		,,	In the proportion as heretofore, according to the numbers requiring it.	
Laboratory tents * complete, with poles, pins, and mallets		5	1 for 20 pieces.	
Collar-makers' Materials for Three Months.				
Harness leather	Stout hides	14	1 hide	to 100 sets of single harness.
	Light do.	7	½ ditto	
Basils.—Dozens, of sorts		28	2 dozen	
Webb	Gunners' girth, yards	112	8 yards	
	Surcingle do.	42	3 yards	
Pannel serge, yards		70	5 yards	
Does' or curled hair, lbs.		210	15 lbs.	
Thread	Hemp, lbs.	42	3 lbs.	
	Collar, ,,	28	2 lbs. each	
	Dutch ,,	28		
Harness and bridle buckles, of sorts, dozens		42	3 dozen	
Nails, of sorts		7000	500 nails	
Tacks, of sorts		7000	500 tacks	
Bristles, lbs.		7	½ lb.	
Needles, of sorts		1400	100 needles	
Whip-cord, lbs.		21	1½ lb.	
Tin pans for oil		42	3 pans	
Wax	Black, lbs.	14	1 lb.	
	Bees' ,,	7	½ lb.	
Neats' foot oil, gallons		21	1½ gallons	
Tallow		14	1 lb.	
Punches, of sorts		140	10 punches	
Awls		140	10 awls	

* *Vide* 'Castrametation,' p. 217.

TABLE VI.*

General Return of Ordnance, Carriages, Ammunition, and Stores, which composed the Battering Train employed on the North Coast of Spain, with the Expenditure at the Siege of St. Sebastian.

Passages, 31st December, 1813.

ARTILLERY STORES.

		Total sent from England.	Left at † St. Sebastian.	Expended at the Siege.
Ordnance	24-pounders	75	23	1
	18 „	8	8	„
	8-inch howitzers	24	„	„
	68-pounder carronades	16	„	„
	13-inch mortars	4	„	„
	10 „ „	20	„	1
Travelling carriages, with limbers complete	24-pounders	73	„	1
	18 „	„	„	„
	8-inch howitzers	32	„	„
Block trail carriages	68-pounder carronades	16	„	„
Iron beds for mortars	13-inch	4	„	„
	10-inch	20	„	1
Platform carriages for guns and mortars		90	„	„
Traversing platforms, complete	24-pounders	15	4	„
	18 „	8	2	„
Flanders pattern waggons		106	„	„
Store limber carriages		32	„	„
Sling carts		3	1	„
Hand carts		16	6	„
Standing carriages	24-pounders	17	13	„
	18 „	9	9	„
Trench carts		16	6	„
Devil carriages		1	„	„
Forge waggons, complete, with bellows, &c.		25	„	„
Handspikes	common	1275	116	102
	traversing 8-inch howitzers	56	„	20
Sponges, with staves, rammers, and bags	24-pounders	150	10	50
	18 „	16	16	„
	8-inch howitzers	48	„	13
	68-pounder carronades	32	„	„
	13-inch mortars	8	„	„
	10 „ „	40	„	„
Spare sponge staves	24-pounders	73	9	28
	18 „	8	8	„
	8-inch howitzers	24	„	10
	13-inch mortars	4	„	„
	10 „ „	20	„	8
Wadhooks	24-pounders	75	3	15
	18 „	8	8	„
	68-pounder carronades	16	„	4
Ladles, with staves	24-pounders	48	3	9
	18 „	8	8	„
Lintstocks		88	9	15

* From Mr. Butcher, Ordnance Storekeeper, Dublin;—and at St. Sebastian, 1813.

The whole of these stores, with perhaps 1-10th of their bulk of Engineer stores, were shipped in 24 transports; of which 22 averaged 313 tons each,—the other two were 588 and 625;—in all, about 8100 tons. These vessels, in the Ordnance invoices, were registered in groups of 1500 tons each, and the above items were divided among them in about equal proportions of that amount.

† The purport of this column was misapprehended, or it would not have been inserted, being irrelevant. It merely gives the quantity of stores ordered by the Duke of Wellington to be left behind on the advance of the army after the capture of St. Sebastian.

TABLE VI.—*Continued.*

		Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Field tampions, with collars	24-pounders	76	5	31
	18 „	8	6	2
	8-inch howitzers	28	„	6
	68-pounder carronades	16	„	4
	13-inch mortars	2	„	„
	10 „ „	24	„	20
Muzzle caps	13-inch „	2	„	„
Hand-screws, large		58	„	6
Slow match, cwts.		75¼	4½	28
Spare sponge heads	24-pounders	77	9	19
	18 „	8	6	2
	8-inch howitzers	24	„	8
	68-pounder carronades	16	„	2
	13-inch mortars	4	„	„
	10 „ „	20	„	12
Spare rammer heads	24-pounders	77	9	29
	18 „	8	6	2
	8-inch howitzers	24	„	5
	68-pounder carronades	16	„	1
	13-inch mortars	4	„	„
	10 „ „	20	„	11
Painted covers for	24-pounders	58	„	30
	8-inch howitzers	24	„	8
	Flanders pattern waggons	104	„	6
	Forge waggons	25	„	5
	Ammunition	78	„	5
	Harness	25	„	„
Drag ropes, heavy, pairs		175	„	47
Men's harness, heavy, sets		106	24	31
Aprons of lead,	large	89	11	28
	middling	58	„	15
Claw hammers		230	11	60
Punches for vents		258	26	53
Priming irons, long, sets		147	11	3
Spikes,	spring	28	„	5
	common	760	72	142
Portfire clippers, pairs		160	15	23
Powder horns		147	11	48
Marline, skeins		255	12	36
Hambro' line, skeins		123	„	69
Budge barrels, H. H.		85	14	23
Straps for side-arms		440	„	180
Tallow, lbs.		104	„	32
Grease,	firkins of	37	„	3
	boxes for	248	2	91
French water-buckets		84	„	36
Linchpins		394	13	119
Washers		217	„	74
Clouts,	body	500	„	166
	linch	500	„	166
Clout nails		6,720	„	2,200
Forelocks,	keys	44	„	16
	rings	44	„	16

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Packthread, lbs.	195	13	98
Cases of wood	100	9	45
Junk wads, 24-pounders	121,650	3,300	16,991
Junk wads, 18 "	34,000	1,791	9,209
Junk wads, 68-pounder carronades	700	"	"
Ammunition.			
Number of rounds for 24-pounders, round	101,997	"	43,367
Number of rounds for 24-pounders, case and grape	5,212	"	1,774
Number of rounds for 24-pounders, spherical	17,860	"	1,930
Number of rounds for 18-pounders, round	32,716	"	9,303
Number of rounds for 18-pounders, case and grape	1,400	"	18
Number of rounds for 18-pounders, spherical	4,500	"	150
Number of rounds for 68-pounder carronades and howitzers, round	700	"	"
Number of rounds for 68-pounder carronades and howitzers, case and grape	1,500	"	"
Number of rounds for 68-pounder carronades and howitzers, spherical	11,700	"	2,198
Number of rounds for 68-pounder carronades and howitzers, common shells	15,000	"	7,672
Number of rounds for 68-pounder carronades and howitzers, carcasses	200	"	"
Number of rounds for 13-inch mortars, common shells	1,694	"	"
Number of rounds for 13-inch mortars, carcasses	103	"	"
Number of rounds for 10-inch, common shells	9,380	"	3,675
Number of rounds for 10-inch, carcasses	220	"	"
Iron, round, 1-lb. shot	114,200	"	7,700
Bottoms of wood for ditto	1,092	"	56
Valenciennes composition, lbs.	1,582	"	380
Powder, L. G., barrels, 90 lbs. each	15,674	638	5,579 barrels, and 5 lbs.
Powder, L. G., barrels, 45 lbs. each	"	"	"
Powder, F. G., lbs.	168	17	22½
Powder, Mealed, lbs.	53	"	11
Cartridges, Filled, 24-pounders, 8 lbs.	40*	3,408*	"
Cartridges, Filled, 24-pounders, 3 lbs.	320	"	"
Cartridges, Filled, 24-pounders, 6 oz.	320	"	"
Cartridges, Filled, 18 " 6 lbs.	"	755	"
Cartridges, Filled, 68-pounder carronades and 8-inch howitzers, 4 lbs.	"	86	"
Cartridges, Filled, 68-pounder carronades and 8-inch howitzers, 3 lbs.	200	47	"
Cartridges, Empty, 24-pounders, 8 lbs.	100,850	18	53,882
Cartridges, Empty, 24-pounders, 3 lbs.	17,498	"	2,500
Cartridges, Empty, 24-pounders, 2 lbs.	35,000	"	4,400
Cartridges, Empty, 24-pounders, 6 oz.	17,498	"	5,250
Cartridges, Empty, 18-pounders, 6 lbs.	24,500	3,216	6,284
Cartridges, Empty, 18-pounders, 2 lbs.	4,500	"	1,500
Cartridges, Empty, 18-pounders, 1½ lb.	9,000	"	
Cartridges, Empty, 18-pounders, 5 oz.	4,000	"	1,000
Cartridges, Empty, 68-pounder carronades and 8-inch howitzers, 4 lbs.	8,222	"	3,750
Cartridges, Empty, 68-pounder carronades and 8-inch howitzers, 3½ lbs.	30,000	"	15,000
Cartridges, Empty, 68-pounder carronades and 8-inch howitzers, 2 lbs.	6,000	"	"
Cartridges, Empty, 68-pounder carronades and 8-inch howitzers, 1 lb. 14 oz.	15,000	"	4,000
Cartridges, Empty, 68-pounder carronades and 8-inch howitzers, 15 oz.	11,700	"	2,700
Tubes, brass	330,000	6,000	84,232
Tubes, tin	16,980	5,280	2,420
Portfires	21,709	352	9,114

* Filled on the spot,—cartridges sent out empty.

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Portfires, blue paper	256	176	67
Portfire sticks	294	,,	82
Tube boxes	292	13	38
Cutting knives	156	17	51
Scissars	156	17	49
Worsted	lbs. oz. 21 3½	,,	,,
Needles	398	,,	118
Thumbstalls	276	,,	73
Flax, lbs.	67	,,	7
Tow	lbs. oz. 19 2	,,	lbs. oz. 4 2
Mallets and setters	60 : 132	,,	8 : 37
Files	248	,,	23
Rasps	62	,,	18
Tenon saws	56	,,	,,
Diagonal scales	130	,,	46
Coarse twine, lbs.	144	,,	69
Perpendiculars	58	,,	18
Quadrants, brass	58	,,	2
Compasses, brass	61	,,	7
Pincers, pairs, copper	98	,,	29
iron	29	,,	4
Copper salting boxes	28	,,	3
Cork-screws	130	,,	24
Spoke-shaves	58	,,	5
Wood vices	98	,,	8
Fuze augers	92	,,	17
Funnels, copper	48	,,	,,
tin	80	,,	7
Funnels, tin, for loading mortars	24	,,	,,
Copper powder measures, 4 lbs.	45	8	,,
2 lbs.	65	8	,,
1 lb.	56	8	1
8 oz.	44	,,	4
4 oz.	42	,,	1
2 oz.	40	,,	,,
1 oz.	40	,,	1
Dutch thread, lbs.	168	,,	60
Scrapers for shells	37	,,	,,
Cartouches of leather, large	330	30	108
Sheepskins	110	,,	47
For spherical fuzes. Tin boxes, white	96	,,	5
blue	96	,,	5
black	96	,,	5
Canvass bags, yellow	96	,,	4
red	96	,,	4
green	96	,,	4
Leather straps for boxes	118	,,	46
bags	118	,,	46

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Fuzes, common, 13-inch	1,900	,,	,,
Fuzes, common, 10 ,,	18,450	,,	5,495
Fuzes, common, 8 ,,	30,000	,,	10,440
Fuzes, spherical, 8-inch, uncut	9,000	,,	3,000
Fuzes, spherical, 8-inch, cut	54,000	,,	4,120
Fuzes, spherical, 5½ ,, uncut	24,700	,,	3,948
Fuzes, spherical, 5½ ,, cut	107,598		
Quick match, lengths	180,201	,,	,,
Engines for drawing fuzes	28	,,	,,
Shell-hooks, pairs	72	,,	15
Tangent scales, brass	,,	,,	,,
Lead plummets	27	,,	,,
Copper scales, with beams	28	,,	,,
Brass weights, sets, 4 lbs. to ¼ oz.	30	,,	,,
,, ,, ,, 2 lbs. to ¼ oz.	4	,,	2

General Stores.

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Triangle gyns, complete, with blocks, &c.	16	1	3
Triangle gyns, incomplete	,,	,,	,,
Cambeons*	,,	,,	,,
White rope, Fathoms, 6-inch	38	,,	,,
White rope, Fathoms, 4 ,,	98	,,	,,
White rope, Fathoms, 2½ ,,	1,130	,,	,,
White rope, Fathoms, 1 ,,	130	,,	,,
White rope, Coils, 6½ ,,	2	,,	1
White rope, Coils, 6 ,,	1	,,	,,
White rope, Coils, 5 ,,	,,	,,	,,
White rope, Coils, 4½ ,,	5	,,	,,
White rope, Coils, 4 ,,	4	,,	2
White rope, Coils, 3½ ,,	4	,,	,,
White rope, Coils, 2½ ,,	65	,,	20
White rope, Coils, 1 ,,	16	,,	5
White rope, Coils, ½ ,,	15	,,	5
Tarred rope, ends, old	,,	,,	,,
Tarred rope, coils, 4½-inch	7	,,	2½
Tarred rope, coils, 3 ,,	5	,,	1
Tarred rope, coils, 2 ,,	5	,,	1
Tarred rope, coils, 1 ,,	9	,,	2
Purchase-blocks, with brass sheaves, treble	5	,,	,,
Purchase-blocks, with brass sheaves, double	5	,,	,,
Purchase-blocks, with brass sheaves, single	4	,,	,,
Spun-yarn, coils	16	,,	3
Ratline, ditto	8	,,	2
Grates for heating shot, complete, with tongs, &c.	13	,,	,,
Junk, cwts.	98	,,	,,
Coals, chaldrons	13	,,	4
Candles, lbs.	896	,,	280
Crab capstan, complete	1	,,	,,

* The long wooden joints of the centre chain of bullock harness.

TABLE VI.—*Continued.*

			Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Spare wheels for	24-pounders,	gun	57	,,	17
		limber	41	,,	11
	8-inch howitzers,	gun	24	,,	8
		limber	16	,,	6
	Devil carriages,	fore	,,	,,	,,
		hind	1	,,	,,
	Platform carriages,	fore	85	,,	,,
		hind	85	,,	10
	Ammunition waggons,	fore	12	,,	4
		hind	12	,,	4
	Forge waggons		25	,,	6
	Store limber carriages		40	,,	3
Iron,	Assorted, tons		4	,,	,,
			cwt. qrs. lbs.		
	Flat,	$6 \times \frac{3}{8}$, $5 \times \frac{5}{8}$, $2 \times \frac{1}{2}$	17 1 17	,,	,,
		$1\frac{1}{2} \times \frac{1}{2}$	6 0 24	,,	,,
	Round,	$1\frac{1}{2}$	1 1 24	,,	,,
		$1\frac{1}{4}$	1 2 4	,,	,,
	Rod,	$\frac{1}{2}$ square, $\frac{1}{2}$ round	8 1 14	,,	,,
	Bolstaff		5 2 0	,,	,,
	Sheet		0 0 14	,,	,,
	Rolled plate, $6 \times \frac{1}{8}$		4 0 16	,,	,,
	Square,	1 inch, $\frac{7}{8}$,,, $\frac{3}{4}$,,	26 2 13	,,	,,
	Casement		11 0 14	,,	,,
					cwt. qrs. lbs.
Steel,	Sheer		6 2 14	,,	5 0 0
	Blister		2 0 14	,,	0 2 0
Horse harness, sets,	Rope trace,	wheel	356	,,	,,
		leader	418	,,	,,
	Chain, trace, thill		37	6	,,
Whips,	long		9	,,	,,
	short		405	,,	,,
Leggins for drivers			387	,,	,,
Head-stall halters, with chain reins			774	,,	,,
Couples for traces			87	12	,,
Stoppers and laniards			54 & 88	,,	,,
Bit halters			37	6	,,
Wanties			24	2	,,
Park pickets			20	,,	,,
Grease, kegs			362	,,	90
Tallow, firkins			9	,,	3
Hand-crow levers,	6 feet		172	24	44
	5 feet		84	,,	24
Iron crows,	$5\frac{1}{2}$ feet		62	,,	13
	$4\frac{1}{2}$ feet		40	,,	14
Tanned hides			115	7	2
Wadmilltilts			77	,,	10

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Hair cloths	48	6	4
Tarpaulins, large	90	,,	10
Tarpaulins, small	800	,,	200
Corn sacks	410	100	,,
Chests of tools for Wheelers	25	1	,,
Chests of tools for Carpenters	9	,,	,,
Chests of tools for Smiths	22	1	,,
Chests of tools for Farriers	2	1	,,
Chests of tools for Collar-makers	9	2	,,
Chests of tools for Coopers	8	,,	,,
Chests of tools for Tinmen	6	,,	,,
Chests of tools for Forge carts	25	,,	,,
Coopers' jointer-planes	4	,,	1
Coopers' tools, sets	,,	,,	,,
Shoes, with nails, sets, Horse	5,500	,,	,,
Shoes, with nails, sets, Mule	5,000	,,	,,
Bellows, pairs, Smiths'	4	,,	,,
Bellows, pairs, Forge cart	6	,,	,,
Lanthorn, Muscovy	80	,,	10
Lanthorn, Tin	132	,,	,,
Lanthorn, Dark	84	,,	,,
Oil, gallons, Linseed	40	,,	,,
Oil, gallons, Train	40	,,	,,
Oil, gallons, Sweet	41	,,	,,
Oil, gallons, Neatsfoot	55	,,	,,
Spirits of turpentine, gallons	12	,,	,,
Paint, lead colour, cwts.	12	,,	3
Paint brushes, large	24	,,	,,
Paint brushes, small	24	,,	,,
Brushes, Pound, 0 0 0	4	,,	,,
Brushes, Pound, 0 0	4	,,	,,
Brushes, Pound, 0	4	,,	,,
Brushes, Sash tools, No. 8	4	,,	,,
Brushes, Sash tools, ,, 6	16	,,	,,
Brushes, Sash tools, ,, 3	16	,,	,,
Copper Adzes	31	2	2
Copper Drivers	46	2	5
Copper Vices	31	2	3
Copper Can-hooks, pairs	27	,,	,,
Hammers, Wrench	48	,,	12
Hammers, Claw	,,	,,	,,
Iron shot-guages, sets	7	1	,,
Spikes, marline	80	,,	17
Twine, lbs.	19	,,	,,
Hambro' line, skeins	175	,,	25
Borax, lbs.	8	,,	2
Spelter, lbs.	8	,,	2
Rosin, lbs.	8	,,	2
Tin, sheets	400	,,	,,
Charcoal, bushels	40	,,	,,
Searchers, with reliefs	4	,,	1

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Union flags, large	8	,,	1
Union flags, small jacks	8	,,	2
Ordnance jacks	8	,,	1
Flag staves	8	,,	1
Brass callipers, large, pairs	7	,,	,,
Screws, of sorts, grosses	46	,,	10
Tacks, of sorts, in No.	65,000	,,	,,
Tacks, of sorts, in weight	lbs. oz. 10 12	,,	,,
Nails in No. Clasps, 40-penny	22,000	,,	,,
Nails in No. Clasps, 30 ,,	29,250	,,	,,
Nails in No. Clasps, 20 ,,	50,400	,,	,,
Nails in No. Clasps, 10 ,,	45,500	,,	,,
Nails in No. Clasps, 8 ,,	40,000	,,	,,
Nails in No. Clasps, 6 ,,	44,000	,,	,,
Nails in No. Clout, 6 ,,	21,000	,,	,,
Nails in No. Clout, 4 ,,	22,000	,,	,,
Nails in No. Clout, 3 ,,	13,000	,,	,,
Nails in No. Clout, 2 ,,	43,000	,,	,,
Nails in No. Streaks, of sorts	8,500	,,	,,
	cwt. qrs. lbs.		cwt. qrs. lbs.
Nails in weight, Clasp, 40-penny	16 0 8	,,	10 2 24
Nails in weight, Clasp, 30 ,,	4 0 24	,,	,,
Nails in weight, Clasp, 20 ,,	10 3 0	,,	8 2 20
Nails in weight, Clasp, 10 ,,	2 1 8	,,	2 0 16
Nails in weight, Clasp, 8 ,,	3 2 8	,,	1 3 4
Nails in weight, Clasp, 6 ,,	2 2 0	,,	1 1 0
Nails in weight, Clout, 4 ,,	1 1 10	,,	0 3 26
Nails in weight, Clout, 3 ,,	0 0 25	,,	0 0 12½
Nails in weight, Clout, 2 ,,	0 2 14	,,	0 1 2
Tire nails, 24-pounder carriages	4,500	,,	3,380
Tire nails, 8-inch howitzers	1,200	,,	600
Tire nails, 6-pounders, heavy	1,400	,,	,,
Tire nails, 6-pounders, light	200	,,	,,
Spades	204	,,	50
Shovels	84	,,	20
Axes, Felling	204	,,	50
Axes, Broad	84	,,	20
Axes, Pick	204	,,	50
Hand Hatchets	200	,,	50
Hand Bill	204	,,	50
Spare helves, of sorts	300	,,	,,
Grindstones, with troughs	8	,,	2
Hand-barrows, double	20	,,	,,
Hand-barrows, single	80	,,	20
Saws, Sash	74	,,	24
Saws, Hand	100	,,	40
Saws, Pit	12	,,	3
Saws, Cross-cut	22	,,	4
Setters for ditto, dozens, Hand	100	,,	40
Setters for ditto, dozens, Pit	12	,,	3
Setters for cross-cut saws, dozens	24	,,	6

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Files for cross-cut saws, dozens, Sash	2	,,	1
Files for cross-cut saws, dozens, Hand	100	,,	40
Files for cross-cut saws, dozens, Pit	11	,,	3
Files for cross-cut saws, dozens, Cross-cut	24	,,	6
Pin mauls	7	,,	,,
Wood mauls	5	,,	,,
Linchpins	7	,,	,,
Camp colours	80	,,	30
Oak skidding, 8 × 8 inches, feet, running	800½	,,	185
Deals, feet, running, 3-inch	4,110	,,	690
Deals, feet, running, 2 ,,	200	,,	,,
Deals, feet, running, 1½ ,,	424	,,	112
Deals, feet, running, 1¼ ,,	168	,,	56
Deals, feet, running, 1 ,,	404	,,	108
Deals, feet, running, ¾ ,,	408	,,	108
Deals, feet, running, ½ ,,	412	,,	100
Plank, feet, superficial, Ash, 2½-inch	2,000	,,	399
Plank, feet, superficial, Ash, 2 ,,	2,000	,,	82
Plank, feet, superficial, Elm, 1½ ,,	2,000	,,	1,000
Plank, feet, superficial, Elm, 1¼ ,,	2,000	,,	995
Plank, feet, superficial, Elm, 1 ,,	1,995	,,	1,000
Spare, in the rough, Spokes	850	,,	231
Spare, in the rough, Bars, fore	473	,,	44
Spare, in the rough, Bars, hind	397	,,	60
Spare, in the rough, Bars, splinter	205	,,	10
Spare, in the rough, Bars, sweep	48	,,	12
Spare, in the rough, Bars, master	80	,,	20
Spare, in the rough, Axletrees	25	,,	5
Spare, in the rough, Naves	40	,,	10
Spare, in the rough, Shafts, heavy	4		,,
Spare, in the rough, Shafts, light	4	,,	,,
Spare, in the rough, Under-poles	40	,,	10
Tail pieces	80	,,	,,
Guides, fore	19	,,	5
Guides, hind	21	,,	5
Axletree beds	40	,,	10
Nose bags	830	,,	,,
Forage cords, sets	206	,,	8
Shoeing tools, sets	2	,,	2
Swingletrees	80	,,	20

Collar-makers' Materials.

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Hides, Black, heavy	13	,,	,,
Hides, Black, light	14	,,	,,
Hides, Brown, heavy	8	,,	,,
Hides, Brown, light	8	,,	,,
Hides, Seat	5	,,	½
Hides, White horse	7	,,	,,
Basils, dozens, black	28	,,	,,
Basils, dozens, brown	22	,,	,,

TABLE VI.—*Continued.*

	Total sent from England.	Left at St. Sebastian.	Expended at the Siege.
Wax, lbs. Bees'	12	,,	,,
Wax, lbs. Black	26	,,	,,
Thread, lbs., Hemp	54	,,	,,
Thread, lbs., Collar	21	,,	3
Thread, lbs., lb. Brown	13	,,	,,
Rosin, lbs.	12	,,	,,
Pitch, lbs.	12	,,	,,
Bristles, ozs.	31	,,	,,
Buckles, assorted, dozens	56	,,	,,
Does' hair, lbs.	252	,,	,,
Thongs, Throat	400	,,	,,
Thongs, Top	400	,,	,,
Thongs, Draw	400	,,	,,
Needles, Collar	210	,,	,,
Needles, Stitching	90	,,	,,
Needles, Saddle	50	,,	,,
Flock, lbs.	56	,,	16
Awls, of sorts	200	,,	,,
Hafts, of ditto	74	,,	,,
Punches, sets	12	,,	,,
Rhand twine, lbs.	33	,,	,,
Whip-cord, lbs.	25	,,	3
Brushes, Hand	25	,,	,,
Brushes, Soft	34	,,	,,
Brushes, Water	34	,,	,,
Tin pans for oil	34	,,	,,
Serge, yards	120	,,	,,
Spare.			
Bail hoops, 9-feet	200	,,	50
Master bars	80	,,	20
Swingletrees	200	,,	,,
Axletrees, bound off complete for 24-pounders	15	,,	4
Ditto, ditto, 8-inch howitzers	2	,,	,,

EQUIPMENT, ENGINEER.*—*Vide* 'SIEGE AND ENGINEER EQUIPMENT.'

* The Editors had nearly completed this Article, when notice was received that the subject was in some respects under revision; and that before long the whole matter of 'Engineer Equipment' will most probably receive special and official consideration:—it is with regret, therefore, that this Article stands necessarily postponed to 'Siege and Engineer Equipment.'

EQUIPMENT, NAVAL.

The Tables to this Article give the armament of the different classes of the ships of war in the British service, with the stores supplied by the Ordnance Department. They are useful, and indeed necessary to that department on foreign stations, in order to make such a provision for the navy abroad as may be required when vessels of war touch at those places.

The following memoranda, drawn up by Colonel Munro, Royal Artillery, and presented to a highly distinguished Naval Officer, Admiral Sir Benjamin Hallowell, at the Admiralty, in 1825, and subsequently to Captain the Hon. Sir Henry Duncan, it would appear, led to the equipment explained in Table I.: the Editors of the 'Aide-Mémoire' are indebted to that Officer for these memoranda, and the Service, in the event of a maritime war, will feel the effects of a system which will produce, no doubt, important results.

The Author of this scheme states that, in contemplating this arrangement, he was induced to propose this particular piece of ordnance (the 32-pounder gun) as the maximum and only calibre adapted for the armament of ships of war, in considering the several naval actions where we had been successful, and where we had used the largest calibre, the 32-pounder gun of 56 cwt., as well as those frigate actions where we had been unsuccessful, and used the naval gun, the long 18-pounder; also that he had heard Naval Officers assert that our seamen would fire the 32-pounder lower-deck guns four or five times, whilst the French fired their 36-pounders (equal to our 42-pounders) three times; and that our 18-pounder gun could not cope with the American 24-pounder long gun; and with the view of having one uniform calibre in each ship of war, submitted the following:—

" Memorandum relative to a proposed and very superior armament for the navy, suggested in consequence of facts connected with the last war with America, and founded on a belief that our ships, in some instances, were lost entirely from the difference of metal between them and their antagonists.

" Woolwich, 1825. " Alex. Munro."

" 1st. There should be no different calibre in any ship. Every shot or shell should be applicable to any piece of ordnance in the ship.

" 2nd. This may be most easily obtained by modifying the guns from the lower decks of the line-of-battle ships, in proportion, until reaching a scale established as a minimum for guns on the quarter decks or poops.

" 3rd. That the calibre should be that of a 32-pounder.

" 4th. That instead of the present 32-pounder carronade, guns constructed on the modified scale should be adopted, or carronades of a new construction with trunnions; but the carronade is altogether a most objectionable piece of ordnance.

" 5th. That for the smallest class of line-of-battle ships, or frigates which now only carry 18-pounders on their main decks, modified 32-pounder guns (equal in weight, viz., 42 cwt., to the present 18-pounders) should be cast; and hollow shot or plugged 32-pounder shells should be used.

" 6th. That instead of the 32-pounder carronades, with which our 18-gun brigs and vessels of that description are now armed, guns weighing about 25 cwt. should be used. That these guns should or might be fired with a charge of 4lbs. of powder, and when near an enemy, with two hollow shot at each round.

"Twelve of the proposed modified 32-pounders, each weighing 25 cwt., would be little more than the same quantity of metal now on the deck of an 18-gun brig armed

with the present carronades; but it is believed that with ten of such modified guns, capable of firing two hollow shots or shells in close action, or with a round of grape and round shot together, these brigs, then called *ten-gun* brigs, would be equal, if not superior, in force to what they now are. The men would have better quarters at their guns; and the brigs might be relieved from the weights of metal now near the stem and stern, by a different position of the six or five ports on a side, instead of nine or ten.

" The guns proposed are,

"First. The present 32-pounder; weight 57 cwt., charge 10 lbs.	When mounted on lower decks of line-of-battle ships.
"Secondly. Modified* 32-pounders; weight 42 cwt. (equal to present 18-pounder), charge 5 or 6 lbs.	Main decks and in frigates, and hollow shot when close, or charge equal to 1 round grape and 1 round shot.
"Thirdly. Second class modified* 32-pounders; weight 25 cwt., charge 3½ or 4 lbs.	Quarter decks, forecastle of frigates and line-of-battle ships, decks of 18-gun brigs and all smaller vessels."

It may be assumed, therefore, that the principle laid down in the foregoing Memorandum has been happily adopted, by referring to Table I.; and thus the confusion incident to guns of several calibres being placed in one vessel avoided, and the power of the armament greatly increased.

It must be admitted that there is a maximum calibre at which the shot is capable of penetrating the sides of ships of war, and destroying every thing it meets, combined with the facility of working the piece of ordnance adapted to naval armaments, and the armament of coast defences, and that is considered to be the 32-pounder gun, as preferable for broadside guns. The 42, 56, 68, and 84-pounder guns, no doubt valuable for special cases, will make a larger hole in the sides of a vessel, and a corresponding destruction; but as the weight and length are increased, so the celerity of fire decreases, and a number of men to work these heavy pieces of ordnance must be added.

It is therefore to be wished that these ponderous and unwieldy descriptions of ordnance should be limited in naval warfare to a few in each vessel. About one-tenth of the whole armament, as will be seen in Table I., is now established as a principle.

These remarks are induced from a desire evinced by some influential persons, of arming vessels of war with the 42-pounder gun. The French seem disposed to abandon their 36-pounder, and adopt the 30-pounder of 6·457 inches diameter, English measure.

Vide 'Artillery' Tables A. B. C. D.

The Tables to the article 'Artillery' will give the weights and dimensions of the several pieces of ordnance now used in the armament of ships of war. Table II. of this article gives their ranges. It has been explained in 'Artillery' that the Ordnance Department supply all artillery stores, ammunition, and guns to the navy, and hence the advantage to the Service generally for a perfect knowledge of the description and nature of these articles.

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* This 'Modification' to suit different vessels, or different decks in the same vessel, has been in some respects met by the introduction of Monk's A. B. C. 32-pounders,—and in others by the 24-pounder and 18-pounder 'bored up' to the same calibre. *Vide* 'Artillery' Table A.—*Editors.*

TABLE I.

Proportion of Guns and Carronades to be issued to Her Majesty's Ships.

ORDNANCE.	First-Rate. Classes. Class 120.	Class 110.	Class 104.	Second-Rate. Classes. Class 92.	Class 84.	Class 80.	Third-Rate. Classes. Class 78.	Class 72.	Class 70.	Fourth-Rate. Classes. Class 50.	Class 50.	Class 50.	Fifth-Rate. Classes. Class 44.	Class 38.	Class 36.	Sixth-Rate. First Class. Class 26.	Class 24.	Class 20.
Guns. 12-inch, Millar's	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8 ,,	6	10	6	10	8	12	6	4	6	6	6	4	2	2	4	2	—	—
32 heavy	28	50	24	56	24	20	26	24	22	22	22	—	—	—	18	—	—	—
32 bored up	72	50	64	26	36	48	36	32	42	22	22	46	30	28	14	24	24	20
24 heavy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24 bored up	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18 heavy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18 bored up	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6 (Brass Field Piece)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—	—
Carronades. 68†	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
42	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	14	—	10	—	16	—	10	12	—	—	—	—	12	8	—	—	—	—
24	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	—	—	—
18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brass 24-pr. howitzer	1	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—

ORDNANCE.	Sixth-Rate. Second Class. Class 26.	Class 26.	Class 18.	Sloops. Classes. Class 20.	Class 18.	Class 18.	Sloops. Classes. Class 16.	Class 16.		Steamers. Classes.			Brigs. Classes. Class 10.	Class 3.	Class 8.	Cutters and Schooners. Classes. Class 3.		
Guns. 12-inch, Millar's	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32 heavy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32 bored up	24	2	18	2	18	2	4	2	—	—	—	—	—	1	—	1	—	—
24 heavy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24 bored up	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18 heavy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18 bored up	—	6	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6 (Brass Field Piece)	1	1	—	—	—	—	—	—	—	1*	1*	—	—	—	—		—	—
Carronades. 68†	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
42	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
32	—	18	—	18	—	16	12	14	—	—	—	—	—	—	—	2	—	—
24	—	—	—	—	—	—	—	—	—	2*	2*	—	—	2	—	—	—	—
18	—	—	—	—	—	—	—	—	—	—	—	—	8	—	—	—	—	—
12	2	2	2	1	1	1	1	1	—	1*	1*	1*	1	1	1	1	—	—
9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Brass 24-pr. howitzer	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

* Boat's guns.

The armament of steam ships differs very much; some carry the 68-pounder gun of 113 cwt. at the bow and stern, with four 8-inch guns of 65 cwt. as broadside guns; others, the 10-inch gun of 84 cwt. as bow and stern guns, with four 8-inch guns, or four 40 cwt. 32-pounders, as broadside guns; others, 10-inch guns as bow and stern guns, with two 8-inch guns, or four 25, as broadside guns; others, the 8-inch gun as bow and stern guns, with two 25-cwt. guns on the broadside. *Vide* 'Artillery' Tables A. B. C., and Table II. of this Article.

† A bad and very troublesome gun: the 42 and 32-pounder are scarcely better.—*Ed.*

TABLE II.

Ranges of the New Naval Guns.

	Weight.	Length.	Charge.	P. B.	2°	3°	4°	5°	7°	9°	12°	15°
	cwt. qr. lbs.	ft. in.	lbs.	yards.	yards.	yards.	yards.	yards.	yards.	yards.	yards.	yards.
10-inch gun	85 1 7	9 4	12	287	1033	1282	1489	1642	2097	2579	3028	3456
8-inch gun	110 0 0	10 6	18	450	1313	1608	1926					
Ditto	65 2 26	9 0	10	470	1133	1323	1602	1922	2246	2577	3016	3370
56-pounder * (Monk)	97 0 0	11 0	16	490	1390			2260‡			3560	
Ditto † ditto	85 0 0	10 0	14	470	1310	1653	1948	2071			3273	3825
32-pounder ditto	49 1 8	9 0	8	From 380 to 420 yards, according to the charge.	1163	1443	1662	1940	2231	2544	3090	3513
,, ...	44 2 0	8 6	7		1124	1440	1731	1934	2242	2498	3175	3391
,, ...	,,	,,	6		1139	1374		1900				
,, ...	40 3 22	8 0	8		1183	1486	1607	1703	2372	2472	2919	3284
,, ...	,,	,,	6		1185	1476	1792	1894	2305	2514		3546
For the ranges and charges, &c. of the bored-up guns, see 'Artillery' Table F.												
Memorandum.—For comparison with the above—												
32-pounder (old)	56 0 0	9 6	10	400	1130			1964			3030	

* Introduced into the Naval Service since the formation of 'Artillery' Tables A. E.

† In 'Artillery' Table A. the dimensions of this gun were not given, as it was not then adopted in the Service; in anticipation, however, the last line in that Table was left blank, and may now be filled in as follows:

		AB.	AC.	AD.	AE.	AF.	AG.	AH.	AI.	AJ.	A.	C.	D.	F.	G.	H.	I.	J.
S. M′.——10′ 0″	cwt. 85	14·8,	4·8,	25·62,	45·75,	54·0,	57·6,	106·8,	117·35,	120·0	27·6,	25·92,	24·7,	20·8,	19·5,	13·82,	17·25,	12·25

| 7·65, 6·5, 36·0 | 9·8, 2·3 | 7·65, 113·75.—No chamber.

‡ 8°—2760.

TABLE III.

Ordnance Naval Stores.

SHIP ORDNANCE.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.	
Cartridge boxes, leather	Two to each carronade. Three to each gun, except Millar's large guns. Four to each of Millar's guns of 10 inches (84 cwt.), and those of larger calibre.												
Chisels, steel, for removing tampions	One to each gun and carronade.												
Crows, iron, 5½ feet, for 18-pounder and upward	One to every three guns.												
Crows, iron, 4½ feet, for 12-pounder and below													
Elevating screws, with caps, carronade	For each carronade, with its carriage, an elevating screw, and cap fitted, is always required.												
Elevating screws, with caps, gun	To such guns as require an elevating screw and cap fitted for the following carriages, viz. One to each of the two long chase guns, of each ship, of the smaller classes. One each, for six of the long guns on main deck of frigates, of 42 guns and upwards.												10-inch, 8 „ or 68-pounder, 32-pounder, of 25 cwt. compressing. 6-pounder, brass, field, for service on land.
Flints, for locks	Four to each gun and carronade lock.												
Formers, for making wads	One to every seven guns and carronades; when less than seven, of any calibre, one former allowed.												
Guages (high guage) for shot	One for each calibre of guns and carronades, on board the ship, and for boats.												
Handspikes, 6 feet	Three to each gun.												
Ladles with staves, for guns	On main deck of ships, first to sixth-rate, three to every seven guns. To all other guns and ships, one to every seven guns. One to less than seven guns, of any calibre.												
Locks, brass, for flints, with covers	Five to every four guns and carronades.												
Locks, hammer, for detonating tubes													
Linstocks, with cocks	1	1	1	1	1	„	„	„	„	„	„	„	Not to be kept back when hammer locks and detonating tubes are supplied.

TABLE IV.—*Continued.*

GENERAL STORES, &c.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.	
Baskets, half bushel	12	10	10	8	6	3	2	3	2	1	1	1	
Brooms, hair, magazine, long	2	2	2	2	1	1	1	1	1	,,	,,	,,	
Brooms, hair, magazine, short	2	2	2	2	1	1	1	1	1	1	1	1	
Can-hooks, copper, pairs	4	4	4	4	2	2	2	2	,,	,,	,,	,,	
Chests, with padlock and key to each, for laboratory stores, &c.	1	1	1	1	1	1	1	1	1	,,	,,	,,	At the option of the Captain for small vessels.
Drivers, wood, shod with copper	Two to each ship, if the powder be shipped in barrels.												
Drums, wood, with sticks	2	2	2	2	1	1	1	1	1	1	1	1	
Drum, cords	Two for each drum.												
Drum, heads	Four for each drum.												
Drum, snares	Two for each drum.												
Funnels, copper, for filling shells	One to each ship having shells allowed.												
Funnels, copper, for filling cartridges, &c.	Two to each magazine.												
Hammer, claw	One to each ship.												
Hides, tanned	12	12	12	6	6	4	2	2	1	1	1	1	Captains allowed the option of taking a less number of hides.
Keys, copper, for opening barrels	Three to each magazine.												
Knives, small, laboratory	3	3	3	3	3	2	2	2	2	1	1	1	
Knives, metal, magazine	1	1	1	1	1	1	1	1	1	1	1	1	
Lanthorns, dark	1	1	1	1	1	1	1	1	1	1	1	1	
Lanthorns, Muscovy	2	2	2	2	1	1	,,	1	,,	,,	,,	,,	
Lanthorns, tin	4	3	3	3	2	2	2	2	1	1	1	1	
Luting for barrels and cases	Half an ounce to each barrel and case.												
Match, slow, cwt.	5	4	4	$3\frac{1}{2}$	3	2	1	1	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	
Measures, copper, for powder, 4, 2, and 1 ℔.	One set to each magazine.												The guns and carronades of smaller calibre will not require the measures of 4 ℔s. and 2 ℔s.
Measures, copper, for powder, 8, 4, 2, and 1 oz.	One set to each magazine.												
Nails, rose-head, for packages, No. 16	250	200	200	140	130	100	100	100	100	,,	,,	,,	
Nails, rose-head, for packages, ,, 14	500	400	400	250	250	250	150	200	150	,,	,,	,,	
Nails, rose-head, for packages, ,, 13	1250	1000	1000	750	700	600	300	300	300	,,	,,	,,	

Needles, stitching	40	40	40	30	30	20	12	18	10	6	6	6	
Oil, olive, imperial gallons	10	10	9	6	5	5	3	5	2	1	1	1	Only allowed when powder, &c. is shipped in barrels.
Rivets, copper, for hoops	90	70	70	70	50	30	”	”	”	”	”	”	
Scissors	2	2	2	2	2	2	2	2	2	1	1	1	
Shovels, copper, magazine	One to each magazine.												
Slippers, leather, magazine, pairs	15	13	13	9	8	6	3	3	3	2	2	2	
Snuffers, copper	One to each light room.												
Vices, copper	One to each ship, if the powder, &c. be shipped in barrels.												
Whiting, for putty, &c.	Two pounds to each gun and carronade.												
Worsted	One ounce to each gun and carronade.												
Wrenches, cross-handled; nut	Memorandum.—Required for old pattern carronade carriages only.												
SPARE ARTICLES.													
Axletrees, iron	Two to each steam vessel having 10-inch or 32-pounder guns with compressing carriages.												
Axletrees, wood, common carriage, fore; hind	Two; One to every 14 guns; one of each, when less than 14 guns, of any calibre.												
Axletrees, wood, Marshall's	Two to each deck having carriages of this description.												
Beds, for carriages, elevating, bottom	One to each carriage.												
Beds, for carriages, common	One to every seven (or less number of) carriages.												
Beds, for carriages, stool	Four to each deck having Marshall's carriages.												
Bolts, fighting or housing	Two to each steam vessel.												
Carriages, transporting	Two to each deck having Marshall's carriages.												To a ship having only one or two of Marshall's (breast and breech) carriages a transporting carriage is necessary.
Quoins, for carriages, elevating, bottom	One to each carriage.												
Quoins, for carriages, Marshall's large; small	Four; Four to each deck of these carriages.												
Quoins, for carriages, ship, common large; small	One; One to every seven (or a less number of any calibre) carriages for guns.												
Compressors	Two to each steam vessel.												
Crutches, for Marshall's pattern carriages	One to every four carriages; one to a ship with less than four.												

TABLE IV.—*Continued.*

SPARE ARTICLES.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.
Forelock, keys, iron	Six to each spare axletree.											
Forelock, keys, metal	One to every two carriages, for all guns.											
Forelock, keys, or keys for cap-squares	Four to each steam vessel.											
Handspikes, with rollers	Two to each steam vessel, (in addition to those belonging to the carriages.)											
Handspikes, 7-feet	Four to each steam vessel, (in addition to those belonging to the carriages.)											
Linchpins, iron, common	Two to each spare axletree; one for 6-pounder field carriage brass gun.											
Linchpins, metal, Marshall's carriage	Two to each deck of Marshall's carriages; four to each steam vessel for Millar's gun carriages.											
Linchpins, metal, transporting carriage	Two to each deck of Marshall's carriages; four to each steam vessel for Millar's gun carriages.											
Plugs, for sockets	Twelve to each steam vessel,—the sockets being fixed to the deck.											
Screws, jamming, carronade	One to every eight (or less number of) carriages fitted on compressing principle.											
Screws, jamming, gun	One to every eight (or less number of) carriages for guns, 32-pounders, 25 cwt.											
Sockets, metal	Twelve to each steam vessel; fixed to the deck.											
Trucks for carriages, common, fore	Two to every seven guns; and when less than seven, of any calibre, one fore and one hind allowed.											
Trucks for carriages, common, hind	One to every seven guns; and when less than seven, of any calibre, one fore and one hind allowed.											
Trucks for carriages, Marshall's, breast	Two to each deck of these carriages.											
Trucks for carriages, Marshall's, breech	Two to each deck of these carriages.											
Trucks for carriages, Marshall's, transporting	Two to each deck of these carriages.											
Trucks for carriages, Millar's compressing	Five to each steam vessel.											
Trucks for carriages, elevating, &c., bottom	One to each carriage.											
Washers, iron	One for field carriage 6-pounder brass gun. Two to each ship having Marshall's carriages; also to each steam vessel for Millar's carriages.											
Washers, metal	Two to each ship having Marshall's carriages; also to each steam vessel for Millar's carriages.											

TABLE V.

Ammunition for Ship Ordnance.

Ammunition for Ship Ordnance.	Rates. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.	Charges. Distant.	Full.	Reduced.	
Bearers for shot	Two to each gun of 10-inch, and above that calibre.															
Blue lights	36	36	36	36	36	36	24	24	24	24	24	24				To flag-ships and broad pennants (Commodores), twelve additional allowed.
Cartridges, flannel, filled with powder, ship's establishment, carronade	Fifty to each carronade, full charge.															
Cartridges, flannel, filled with powder, ship's establishment, gun	Eighty to each gun, in proportions of												20	20	40	To guns allowed these charges.
													,,	40	40	To guns *not* allowed distant charges.
													,,	80	,,	To guns *not* allowed distant or reduced charges.
Cartridges, flannel, filled with powder, service in boats, carronade	Fifty to each carronade, full charge.															
Cartridges, flannel, filled with powder, service in boats, gun, 6-pounder, 1 lb. each	50	50	50	50	50	,,	,,	,,	,,	,,	,,	,,				
Cartridges, flannel, filled with powder, short practice, 4 oz. each	1020	1020	840	720	360	120	120	,,	120	,,	,,	,,				
Cartridges, flannel, empty, ship's establishment, carronade	Twenty to each carronade, full charge.															
Cartridges, flannel, empty, ship's establishment, gun	Twenty to each gun, in proportions of												5	5	10	To guns allowed these charges.
													,,	10	10	To guns *not* allowed distant charges.
													,,	20	,,	To guns *not* allowed distant or reduced charges.
Cartridges, flannel, empty, service in boats, carronade	Fifty to each carronade, full charge.															
Cartridges, flannel, empty, service in boats, gun, 6-pounder, 1 lb. each	50	50	50	50	50	,,	,,	,,	,,	,,	,,	,,				

Memorandum.—If a ship cannot stow the whole of the cartridges here regulated, the Captain is to state the same in writing to the Ordnance Storekeeper at the Port, as his reason for not receiving that part of the proportion he desires should be withheld.

TABLE V.—*Continued.*

AMMUNITION FOR SHIP ORDNANCE.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.	
Powder, in flannel bags, containing 15 lbs. each, for ship's establishment, and for the boat's carronades	Twenty rounds for each gun and carronade, viz.												For all carronades, full charge. For 68-pr. guns, and above; full charge. For 32-pounder guns, and lower calibre; reduced charge.
Portfires, for firing rockets, &c.	14	14	14	14	14	14	10	10	10	10	10	10	To flag-ships and broad pennants (Commodores), double supply allowed.
Portfire sticks	2	2	2	2	2	”	”	”	”	”	”	”	
Rockets, with sticks, Congreve's, 24-pounder	60	60	60	60	60	60	”	”	”	”	”	”	Not issued, except by express order.—*Vide* Admiralty Regulation.
Rockets, with sticks, Congreve's, 12 ”	”	”	”	”	”	”	36	36	36	36	36	36	
Rockets, with sticks, signal, 1 lb.	6	6	6	6	6	6	3	3	3	3	3	3	To flag-ships and broad pennants (Commodores), double supply allowed.
Rockets, with sticks, signal, ½ lb.	18	18	18	18	18	18	9	9	9	9	9	9	
Machines or tubes, for firing rockets, Congreve's	Two to each ship, when the rockets are supplied.												
Machines or tubes, for firing rockets, signal, large	One to each ship.												
Machines or tubes, for firing rockets, signal, small	One to each ship.												
For Millar's, or other guns, of 12-inch, shells, with metal fuzes, and fixed to wood bottoms, live, filled with powder	Ten to each gun.							20	For a ship having one of these guns.				
								20	For a ship having two of these guns.				
								10	For each additional gun of these calibres, in any steam ship.				
For Millar's, or other guns, of 12-inch, shells, with metal fuzes, and fixed to wood bottoms, dead, empty	Ten to each gun.							20	For a ship having one of these guns.				Memorandum.—When shells or hollow shot are issued for guns or carronades, the number of either is not to exceed the proportion herein fixed; and the quantity shipped is to be considered as *instead of a like quantity of round shot.*
								20	For a ship having two of these guns.				
								10	For each additional gun of these calibres, in any steam ship.				

Article													Remarks
10-inch, 8-inch, (or 68-pr.) calibre. Shot, hollow or plugged, round	Fifty-five to each gun.							55	For a ship having one of these guns.				
								150	For a ship having two of these guns.				
								75	For each additional gun of these calibres, in any steam ship.				
Shot, tin case	Five to each gun.							5	For each of these guns.				
Memorandum.—Making a total of eighty rounds per gun for all ships except steam ships; and of one hundred rounds per gun for steam ships.													
Shot, grape, ship's establishment, for 32-pounder guns and less calibre	One to each gun on lower and middle decks. Three to every other gun.												
Shot, grape in tin cases, ship's establishment	Three to each carronade.												
Shot, grape in tin cases, boat service	Thirty-six to each carronade.												
Shot, round, ship's establishment, carronades	Fifty to each carronade.												Memorandum.—If any ship or steam vessel can conveniently take more than this proportion of round shot, an additional number will be supplied, on application from the Captain or Commander to the Ordnance Storekeeper at the Port. This is particularly applicable to vessels armed with carronades only, the minimum being fixed at 50 rounds.
Shot, round, ship's establishment, guns, 32-pounder, and less calibre	Eighty to each gun.												
Shot, round, boat service, carronades	Fifty to each carronade.												
Shot, round, boat service, gun, 6-pounder brass	50	50	50	50	50	,,	,,	,,	,,	,,	,,	,,	
Shot, round, short practice, guns, brass, 6-pounder	1020	1020	840	720	360	,,	,,	,,	,,	,,	,,	,,	
Shot, round, short practice, guns, bow, or chase, iron	,,	,,	,,	,,	,,	120	120	,,	120	,,	,,	,,	
Shot, tin case, ship's establishment, carronades	Five to each carronade.												
Shot, tin case, ship's establishment, guns, 32-pounder, and less calibre	N. B.—None to the lower and middle-deck guns; four to every other gun.												
Shot, tin case, boat service, carronades	Thirty-six to each carronade.												
Shot, tin case, boat service, guns, 6-pounder brass	36	36	36	36	36	,,	,,	,,	,,	,,	,,	,,	
Tubes, detonating; Fynmore's pattern	One hundred and fifty to each gun and carronade.												
Tube boxes, with straps	Two to each gun and carronade.												
Tube magazines, copper, portable, Captain Fead's pattern	,,	,,	,,	,,	,,	2	2	,,	2	2	,,	,,	For the two aftermost, or stern guns, or carronades, in each ship or vessel.
Wadsticks, for guns of 12-inch; 10-inch; 8-inch, or 68-pounder	Eighty to each gun for all ships except steam ships; one hundred to each gun for steam ships.												
Wrenches, for fuzes of shells	Two to each gun having shells allowed.												

TABLE VI.—*Small Arms and Ammunition.*

SMALL ARMS AND AMMUNITION.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.
Axes, pole	30	30	30	25	25	20	12	20	10	5	5	5
Boxes for cartridges, musket	2	2	2	2	2	1	1	1	1	1	1	1
Boxes for cartridges, pistol	1	1	1	1	1	1	,,	1	,,	,,	,,	,,
Cartouch boxes with belts, musket	130	130	116	96	60	35	35	40	15	12	12	12
Cartouch boxes with belts, pistol	30	30	26	20	20	15	10	15	10	5	5	5
Flints, musket	11,000	9200	8400	6800	4000	2200	1800	1800	1300	900	900	900
Flints, pistol	1400	1200	1100	700	500	300	300	300	200	200	200	200
Frogs for bayonets, musket	130	130	116	96	60	35	35	40	15	12	12	12
Muskets, with bayonets, scabbards, and steel rammers, long	100	100	90	70	40	20	,,	20	,,	,,	,,	,,
Muskets, with bayonets, scabbards, and steel rammers, short	30	30	26	26	20	15	35	20	15	12	12	12
Pistols with rammers, pairs	30	30	26	20	20	15	10	15	10	5	5	5
Pikes, strong	100	100	100	80	60	50	40	40	35	12	12	12
Swords with scabbards and belts	350	350	280	240	200	100	50	100	35	20	20	20
For Service.												
Cartridges, ball, musket	15,000	15,000	14,000	12,000	8000	4000	3000	3000	3000	1000	1000	1000
Cartridges, ball, pistol	1000	1000	1000	800	800	600	400	400	400	100	100	100
For Exercise and Practice for 3 years.												
Cartridges, ball, musket	10,600	8500	7760	5100	3540	2000	1660	1660	1080	720	720	720
Cartridges, ball, pistol	12,700	10,200	9300	6100	4200	2400	2000	2000	1300	900	900	900
For making up ball and blank cartridges, for muskets. powder, F. G., S. A., (packed in flannel bags, 15 lbs. each) lbs.	1863	1494	1364	896	622	352	292	292	190	127	127	127
paper, reams, quires, fine white	10 3	8 3	7 9	4 18	3 7	1 18	1 12	1 12	1 1	0 14	0 14	0 14
paper, reams, quires, purple	6 2	4 18	4 9	2 19	2 1	1 3	0 19	0 19	0 13	0 8	0 8	0 8
lead ball, cwt., musket	$32\frac{1}{2}$	26	24	16	11	6	5	5	3	2	2	2
thread, lbs., Dutch	21	17	15	10	7	4	$3\frac{1}{4}$	$3\frac{1}{4}$	2	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$
formers, wood, musket	12	12	12	12	12	9	9	9	6	4	4	4
funnels, copper	2	2	2	2	2	2	2	2	2	1	1	1
measures, copper, musket, 6 drams	2	2	2	2	2	2	2	2	2	1	1	1
measures, copper, musket, 5 ,,	2	2	2	2	2	2	2	2	2	1	1	1
Percussion.												
Muskets, with bayonets, scabbards, and steel rammers	25	25	25	25	16	16	12	12	,,	,,	,,	,,
Pistols, with rammers, pairs	6	6	6	6	4	4	3	3	,,	,,	,,	,,
Caps, copper	One hundred and fifty to each musket and pistol.											
Cartridges (in red paper), ball, musket	Sixty to each musket.											
Cartridges (in red paper), ball, pistol	Thirty-five to each pistol.											
Nipples, musket	One to every six muskets.											
Nipples, pistol	One to every six pistols.											
Wrenches, musket	One to every eighteen muskets.											
Wrenches, pistol	One to every eighteen pistols.											

When percussion muskets and pistols are issued t[o] ships, the numbers are to be considered as par[t] of this proportion.

Memorandum.—This quantity of cartridges, powder, and materials, provides for the expenditure every six months of

Twenty, ball } musket, } cartridges,
Ten, blank }
Four, ball, pistol }
assuming the total number of men to be

	Me[n]
1st rate	53
2nd ,,	42
3rd ,,	38
4th ,,	25
5th ,,	17
6th ,,	10
Sloops, &c.	[illegible]
Steamers	[illegible]
Brigs	[illegible]
Schooners, &c.	[illegible]
Packets	[illegible]
Steamers, under 4 guns	[illegible]

When percussion arms are issued, the number is to [be] considered as part of the proportion authorized [for] each rate or description of vessel, as above.

Every ship having arms with percussion locks to [be] allowed one wrench for muskets, and one for pisto[ls]

TABLE VII.—*Packages.*

PACKAGES.	RATES. First.	Second.	Third.	Fourth.	Fifth.	Sixth.	Sloops and Bombs, 16 guns and upwards.	Steamer Sloops.	Brigs under 16 guns.	Schooners, Cutters, &c.	Packets, 4 guns and upwards.	Steamers under 4 guns.
Bags, flannel, to hold 15 lbs. of powder	Sufficient for the powder (not filled into cartridges) for guns, carronades, and small arms.											
Baskets, for covering bottles of glass	One to each.											
Baskets, for covering bottles of stone												
Barrels, metal, lined, with 4 copper hoops on each, whole	When cases are not shipped. Sufficient to contain the filled cartridges for the guns and carronades, for muskets and pistols; also the whole of the powder in flannel bags, for guns, carronades, and small arms.											
Barrels, metal, lined, with 4 copper hoops on each, half												
Barrels, metal, lined, with 4 copper hoops on each, quarter												
Bottles, glass	Sufficient for the oil, &c.											
Bottles, stone												
Bottles, tin												
Boxes for lead ball, or shot, musket	Sufficient for the shot and shells of each description.											
Boxes for lead ball, or shot, pistol.												
Boxes for shot, guns, grape												
Boxes for shot, guns, tin case												
Boxes for shot, carronades, grape in tin cases												
Boxes for shot, carronades, tin case												
Boxes for shells, 12-inch												
Boxes for shells, 10 "												
Boxes for shells, 68-pounder (or 8-inch)												
Casks	Sufficient for the whiting, &c.											
Cases, lined with metal, whole	When barrels are not issued. Sufficient to contain the filled cartridges for the guns and carronades, and for muskets and pistols; also for the whole of the powder in flannel bags, for guns, carronades, and small arms. N. B.—Signal rockets are packed in half cases.											
Cases, lined with metal, half												
Cases, lined with metal, quarter												
Cases, packing, of sorts	Sufficient to contain the empty cartridges, and laboratory small stores, &c.; also for Congreve's rockets, when embarked.											
Hoops, copper (on the barrels), whole	Two bulge hoops and two chime on each barrel.											
Hoops, copper (on the barrels), half												
Hoops, copper (on the barrels), quarter												
Kegs	Sufficient for the flints.											

Note.—Tables IV. V. VI. and VII. of 'Equipment, Naval,' are now in course of re-arrangement, and will, when sanctioned by authority, be inserted in a future Part.

EQUIPMENT, AMERICAN,* for Trains of Artillery,—Armament of Fortifications,—Field Train,—as prescribed by the Secretary at War of the United States.

FIELD TRAIN.

Ordnance.

The proportion of artillery to other troops varies generally between the limits of 1 and 3 pieces to 1000 men, according to the force of the army, the character of the troops of which it is composed, the force and character of the enemy, the nature of the country which is to be the theatre of war, and the character and objects of the war.

Similar considerations must regulate the selection of the kinds of ordnance, and the proportions of the different kinds in the train.

The following principles may be observed in ordinary cases:

2 pieces to 1000 men $\begin{cases} \frac{2}{3} \text{ guns, of which} \begin{cases} \frac{1}{4} \text{ are 12-pounders,} \\ \frac{3}{4} \text{ are 6-pounders,} \end{cases} \\ \frac{1}{3} \text{ howitzers, of which} \begin{cases} \frac{1}{4} \text{ are 24-pounders,} \\ \frac{3}{4} \text{ are 12-pounders,} \end{cases} \end{cases}$

distributed as follows:

For the Infantry: 1 piece to 1000 men,—6-pounder guns and 12-pounder howitzers, in batteries of foot artillery.

For the Cavalry: 2 pieces to 1000 men,—6-pounder guns and 12-pounder howitzers, in batteries of horse artillery.

For the Special and General Parks of Reserve:

1 piece to 1000 men $\begin{cases} \frac{1}{2} \text{ in 12-pounder batteries of foot artillery,} \\ \frac{1}{3} \text{ in 6-pounder ditto ditto,} \\ \frac{1}{6} \text{ in 6-pounder batteries of horse artillery.} \end{cases}$

Ammunition for Cannon.

Two hundred rounds to each piece, both of the reserves and of the active batteries.

The ammunition which cannot be carried in the caissons attached to the pieces will be kept in boxes with the reserves.

Proportion of the different kinds of Ammunition and other Supplies.

Kind.	For Guns.		For Howitzers.		
	12-prs.	6-prs.	24-prs.	12-prs.	
Strapped shot, fixed	76	70	–	–	For 100 rounds.
Canisters, fixed	12	20	–	–	
Strapped shells	–	–	52	48	
Spherical case-shot, strapped	12	10	35	40	
Canisters with sabots	–	–	13	12	
Cartridges, large charge (spare)	6	4	8	6	
Cartridges, small charge	12	10	100	100	
Fuzes	Twice the number of shells and spherical case-shot.				
Portfires	1 to 5 rounds.				
Tubes	½ more than the number of rounds.				
Slow match	1 yard to 5 rounds.				
Quick match	¼ yard to each spherical case-shot.				
Bursters	1 to each shell and spherical case-shot.				

* Ordnance Manual, published by authority of the American Government.

Additional supplies of ordnance and ordnance stores are placed in convenient dépôts, according to circumstances.

Ammunition for Small Arms.

One hundred rounds to each man; of which, for the musket, 40 rounds are in the cartridge box, 60 in the parks of reserve. In the same proportion for other small arms.

Five flints to 100 rounds.

Percussion caps for carbines, half more than the number of cartridges.

Composition of a Battery on the War Establishment.

	Kind of Battery.	12-pr.	6-pr.
Guns . .	12-pounders mounted	4	–
	6-pounders do.	–	4
Howitzers	24-pounders do.	2	–
	12-pounders do.	–	2
	Total number of pieces mounted	6	6
Carriages.	Gun carriages (spare)	1	1
	Caissons	12	6
	Forges (1 for repairs and 1 for shoeing)	2	2
	Battery waggons (1 for repairs, 1 for harness)	2	2
	Total number of carriages	17	11

Implements and Equipments for each Gun Carriage.

2 Gunner's haversacks.
1 Tube pouch.
1 Portfire case.
2 Thumbstalls.
1 Priming horn.
1 Prolonge.
1 Vent-cover and strap.
1 Lintstock.
1 Portfire stock.
1 Priming wire.
1 Fuze auger.
1 Fuze saw.
1 Fuze sett.
1 Vent-punch.
1 Gunner's gimlet.
1 Tangent scale.
1 pair Portfire cutters.
2 Sponges and rammers.
2 Sponge-covers.
½ Worm and Staff.
2 Handspikes.
1 Sponge bucket.
1 Tow-hook.
1 Fuze rasp.
1 Fuze mallet.
1 Shell plug-screw.

For each Howitzer Carriage (additional).

1 Fuze extractor.
1 Copper funnel.
1 Gunner's quadrant.
1 8-oz. Powder measure.

For each Caisson.

1 Felling-axe.
1 Shovel.
1 Pick.
1 Spare pole (one-half of them ironed).
1 Spare wheel, to each caisson of the reserves.
1 Spare handspike.
1 Tar bucket.
3 Tow-hooks.

For each Forge.

1 Water bucket.
1 Shovel.

Draught Horses.—6 to a battery waggon and 12-pounder gun carriage,—4 to other carriages—$\frac{1}{12}$th spare.

Harness,—corresponding with the number of horses to the carriages.

The equipments required for the immediate service of a piece are carried, on the march, in the ammunition chest of the limber.

SIEGE TRAIN.

The number and kind of cannon for a siege train must be determined by the circumstances of each case; but the following general principles may be observed in assigning the proportion of different kinds and calibres, and the relative quantity of other supplies, for a train of 100 pieces of ordnance.

Cannon.

Guns	24-pounder,	about one-third of the whole number	32	100
	18-pounder,	„ one-tenth „	10	
	12-pounder,	„ one-tenth „	10	
Howitzers	8-inch siege,	„ one-eighth „	13	
Mortars	10-inch siege,	„ one-seventh „	14	
	8-inch siege,	„ one-fourteenth „	7	
Stone mortars		„ one-seventh „	14	
Coehorn mortars (in addition to the 100 pieces)			6	
Wall-pieces, for the attack of one front			40	

Gun Carriages.

For 24-pounder guns and 8-inch howitzers,	one-third spare	60
For 18-pounder and 12-pounder guns,	one-fourth spare	25
For 10-inch mortars and stone mortars,	one-third spare	38
For 8-inch mortars and stone mortars,	one-fourth spare	9

Other Carriages.

Transporting carriages for mortars.—1 for each 10-inch mortar and bed, for each stone mortar and bed, and for three 8-inch mortars and beds	38
Waggons, for transporting implements, &c., intrenching and miners' tools, laboratory tools and utensils, and other stores,—each loaded with about 2700 lbs., say	140
Trench carts (carrying balls, &c., on the march)	50
Battery waggons, 1 to 100 horses	28
Forges, fully equipped	8
Sling carts	5

Draught Horses.

For each 24-pounder and 18-pounder gun, and 8-inch howitzer with its carriage	8
„ 12-pounder gun with its carriage	6
„ spare gun carriage and forge	4
„ transporting carriage for mortars	8
„ park and battery waggon	6
„ trench cart	2
„ sling cart	2
Spare horses	$\frac{1}{10}$th
Total, say	1800

Projectiles and Ammunition.

For guns	Round shot	1000 to each 24-pounder	32,000
		1000 to each 18-pounder	10,000
		1200 to each 12-pounder	12,000
	Grape and canister, 50 rounds to each piece		2,600
	Spherical case, 100 rounds to each piece		5,200
For howitzers	Shells . . . 800 to each 8-inch		10,400
	Canisters . . 50 do.		650
	Spherical case 100 do.		1,300
For mortars	600 shells to each 10-inch		8,400
	800 " 8-inch		5,600
	600 " Coehorn		3,600

Gunpowder, in barrels . . . . ℔s. 500,000

Computing for each round shot, ¼th the weight of shot.

" grape, canister, and spherical case, ⅙th the weight of shot.

" round of howitzer ammunition, 5 ℔s. } including charge of shells.
" " 10-inch mortar . . 7
" " 8-inch do. . . 3

" " Coehorn . . . . ½

" " stone mortar . . . 1

Paper cartridge-bags, 400 to each piece	40,000
Cartridge-paper, bundles	200
Sabots, 200 to each gun and howitzer	13,000
Slow match	℔s. 4,500
Portfires	8,000
Priming tubes	80,000
Fuzes, ¼th more than the number of shells	40,000
Wooden bottoms and *baskets* for stone mortars, 800 to each	11,200

Percussion primers, for pieces furnished with locks, ¼ to spare.

Cartridges for wall-pieces, 500 rounds to each.

Cartridges, powder, flints, and *lead*, for small arms, according to the force of the army.

Most of the ammunition is transported by hired waggons.

Implements and Equipments. For each Gun.

3 Sponges—2 spare.
2 Rammers—1 spare.
⅓ Worms.
⅓ Ladles.
8 Handspikes—2 spare.
2 Lintstocks—1 spare.
1 Portfire stock.
1 Pass box.
1 Tube pouch.
1 Priming horn.
2 Thumbstalls.
2 Priming wires—1 spare.
1 Gunner's gimlet.
1 Tangent scale.
2 Mauls.
1 Vent-cover.
1 Sponge bucket.
1 Broom.
1 Percussion lock.

For each Howitzer and Mortar.

Implements.	Howitzer.	Mortar.
Sponges and Rammers	3 — 2 spare	2 — 1 spare
Ladles	⅓	. .
Handspikes (2 shod, for mortar)	6 — 2 spare	6 — 2 spare

Implements.	Howitzer.	Mortar.
Lintstocks	2 — 1 spare	2 — 1 spare
Portfire stocks	1	1
Haversacks	1	1
Priming wires	2 — 1 spare	2 — 1 spare
Gunner's gimlets	1	1
Quadrants	1	1
Mauls	2	2
Fuze drifts	2 — 1 spare	* 2 — 1 spare
Mallets	2 — 1 spare	* 2 — 1 spare
Baskets	1	1
Tampions	1	1
Sponge bucket	1	1
Broom	1	1
Percussion locks	1	–
Plummet	–	1
Pointing wires	–	* 2
Quoins	–	2
Shell-hooks	–	* 2 — 1 spare
Scrapers	–	1
Spatulas	–	* 1
Gunner's sleeves (pair)	–	1
Sand-bags, to wipe with	–	1

Scales and weights, funnel, set of powder measures of three sizes, shell plug-screw, and fuze extractor, to each battery magazine.

Implements marked * are not required for the stone mortar: the number of implements must be proportioned to the whole number of gun carriages, including the spare carriages.

Platforms.

For guns and howitzers,	one-tenth spare	72
For mortars,	one-eighth spare	40

Embrasure Shutters.

Half the number of guns and howitzers 33

Spare parts of carriages, &c. (*See 'Armament of Fortifications.'*)
Spare parts of field carriages, as for field batteries.

Timber, and other Materials, for Repairs.

Proportion to the number of parts that enter into the construction of the carriages:

Axle bodies for siege carriages, $\frac{1}{50}$th—breech bolsters, $\frac{1}{20}$th—cheeks, $\frac{1}{30}$th—felloes, $\frac{1}{50}$th—spokes, $\frac{1}{30}$th—fork saddles, $\frac{1}{30}$th—poles, $\frac{1}{20}$th—hounds, $\frac{1}{20}$th—splinter-bars, $\frac{1}{20}$th—double trees, $\frac{1}{10}$th—square timber of various scantling—plank—wooden part of transporting carriages; of each $\frac{1}{20}$th.

Bar iron assorted, 80 lbs. to a piece, 8000 lbs.—steel, 5 lbs. to a piece, 500 lbs.—sheet iron, 50 sheets—iron wire, 400 lbs.—sheet tin, 100 sheets—nails and screws assorted.

Machines and Ropes.

Seven gyns, with tacle, complete—34 lever-jacks—14 jack-screws—20 wheel-barrows, $\frac{1}{5}$th for shells—7 hand-barrows—balances for weighing—10 spare gyn falls—75 double prolonges—75 single prolonges—drag-ropes, 200—trace-ropes, 300—men's harness, 50—small ropes, 200 lbs.—twine, of various sizes, 50 lbs.

Tools.

Sets of carriage-makers' and blacksmiths' tools—pioneers' tools, for the Artillery alone, 40 to a piece, say 4000; of which, 1600 spades, 270 shovels, 2000 mattocks, 130 picks—spare tool-handles, $\frac{1}{2}$. Axes, 5 to a piece, 500—bill-hooks, 10 to a piece, 1000—saws, various kinds, 200—10-ft. rods, 2-ft. rules, masons' levels, 100 of each—paviours' rammers, 200—mauls, 200—scythes, 8—miners' tools—baskets.

Laboratory Tools and Materials.

Two sets of laboratory tools:

Nitre, pulverized	1500 lbs.	Twine	50 lbs.
Sulphur, pulverized	100 ,,	Tarred rope-yarn	200 ,,
Sulphur, roll	100 ,,	Copper wire	10 ,,
Pitch	150 ,,	Brass wire	10 ,,
Rosin	150 ,,	Cotton yarn	25 ,,
Bees' wax	50 ,,	Glue	10 ,,
Charcoal, pulverized	200 ,,	Wrapping-paper	10 reams.
Camphor	20 ,,	Tar	20 barrels.
Spirits turpentine	10 gallons.	Mealed powder	300 lbs.
Sperm oil	5 ,,	Quick match	150 ,,
Linseed oil	2 ,,	Torches	100 ,,
Tow, tarred links, fire-stone, &c., &c.			

Instruments, Books, &c.

Two theodolites, or other instruments for measuring angles—2 levels and staves—2 compasses—4 surveying chains—diagonal scales—cases of mathematical instruments—spy-glasses—tables of artillery construction—tables of firing—logarithmic tables—drawing-paper.

Miscellaneous Supplies.

Smiths' coal, 20 tons—grease, in barrels—sand-bags, 500 to each piece of ordnance—chevaux-de-frize—scaling ladders—rampart grates, 50—tarpaulins, various sizes, 100—2 grind-stones—lanthorns, 100—sperm candles, 150 lbs.—lamp-lighter's torches—tinder-boxes, &c.—canvass.

ARMAMENT OF FORTIFICATIONS.

The kind and number of pieces of ordnance required for the armament of each of the fortifications are prescribed by the Secretary at War, according to their character and extent.

The carriages, ammunition, implements, equipments, and other supplies, for a fort on the war establishment, may be proportioned to the number of pieces on the following general principles, the application of which must, however, be regulated by the importance of the position, and by the peculiar circumstances of each case.

	For a Front of Attack.	For other Land Fronts, and for Sea-Coast Batteries.	
Carriages.			
Gun carriages. Casemate	One-sixth	One-eighth	More than the number of pieces.
Gun carriages. Barbette	One-third	One-sixth	More than the number of pieces.
Gun carriages. Siege	One-third	One-sixth	More than the number of pieces.
Gun carriages. Field	One-third	—	More than the number of pieces.
Gun carriages. Mortar-beds	One-fourth	One-fourth	More than the number of pieces.
Trench carts for advanced works	1 to 20 pieces	—	
Sling carts	1 to 25 „	1 to 25 pieces	
Tumbrils or hand carts	1 to 20 „	1 to 20 „	
Caissons	1 to each field-piece	—	
Forges, travelling (besides permanent forges)	1 to 30 pieces of all kinds	—	
Ammunition.			
For each gun and sea-coast howitzer	800 rounds	250 rounds	$\frac{1}{10}$th grape and canister.
For each carronade	100 „	100 „	$\frac{1}{2}$ grape and canister.
„ siege howitzer	600 „	200 „	$\frac{1}{20}$th grape and canister.
„ 10-inch mortar	400 „	—	
„ mortar	—	200 „	
For 8-inch stone mortar and Coehorn	600 „	—	

100 lbs. of stone to each charge of a stone mortar.

Rampart grenades, 300 to a front of attack.

For each piece of artillery of a battery for sorties, 400 rounds.

Gunpowder.—The quantity of cannon powder may be calculated on the following principles:

For each charge of a gun, $\frac{1}{4}$ of the weight of shot.

„ „ carronade, or 24-pounder howitzer	2 lbs.	
„ „ 8-inch siege howitzer	4 „	
„ „ 10-inch sea-coast do.	12 „	
„ „ 8-inch do. do.	8 „	
„ „ 10-inch mortar (light)	7 „	Including the charge of the shell.
„ „ 10-inch do. (heavy)	15 „	Including the charge of the shell.
„ „ 8-inch do.	3 „	Including the charge of the shell.
„ „ 13-inch do.	30 „	Including the charge of the shell.
„ „ stone mortar	1 „	
„ „ Coehorn	$\frac{1}{2}$ „	

To spare, for mining, fire-works, and waste, $\frac{1}{10}$th of the whole, including a proportion of mealed powder and its components, pulverized.

Fuzes, $\frac{1}{4}$ more than the number of shells.

Tubes, $\frac{1}{2}$ more than the number of rounds.

Slow match, 40 lbs. to a piece.

Cannon cartridge-paper, 1 sheet to a round.

Sabots, wooden bottoms for stone mortars.

Portfires, 1 to 15 rounds.

Percussion primers, $\frac{1}{4}$ more than the number of rounds, for pieces furnished with locks.

Small Arms.

Muskets	$\frac{1}{3}$	More than the number of troops of the several kinds, supposed to be fully armed and equipped.
Musketoons	$\frac{1}{3}$	
Pistols	$\frac{1}{3}$	
Artillery and Infantry swords .	$\frac{1}{25}$	
Cavalry sabres	$\frac{1}{5}$	

Wall-pieces, 50 to a front of attack, or a front exposed to escalade.

Ammunition.	Musket cartridges for each man	400
	Musketoon, pistol, and rifle cartridges . .	100
	Cartridges for each wall-piece	400

Spare powder for small arms, $\frac{1}{25}$th of the whole quantity required for the cartridges; cartridge-paper in proportion.

Flints, 1 to 10 rounds; percussion caps, $1\frac{1}{2}$ to a round, for arms with percussion locks.

Implements and Equipments for each Gun.

2 Rammers — 1 spare.
2 Sponges — 1 spare.
$\frac{1}{3}$ Worms.
$\frac{1}{3}$ Ladles.
2 Lintstocks — 1 spare.
1 Portfire stock.
1 Pass box.
2 Budge barrels.
1 Tube pouch.
1 Priming horn.
2 Thumbstalls — 1 spare.
2 Priming wires — 1 spare.
1 Gunner's gimlet.
1 Hausse, or tangent scale.
1 Vent-cover, or lock-cover.
1 Percussion lock.
1 Water bucket.

For each Howitzer.

The same as for a gun, omitting *Pass box*, and adding —

1 Haversack.
2 Fuze setters.
2 Fuze mallets.
1 Fuze extractor to 6 pieces.
1 Quadrant.
1 Fuze saw.
1 Fuze gimlet.

For each Mortar.

2 Sponges and rammers.
6 Handspikes — 4 shod.
2 Lintstocks.
1 Haversack.
1 Tube pouch.
2 Priming wires.
1 Gunner's gimlet.
1 Quadrant.
1 Plummet.
2 Pointing wires.
2 Quoins.
1 Tampion.
2 Shell-hooks.
1 Scraper.
1 Spatula.
1 pair Gunner's sleeves.
1 Sand-bag.
2 Fuze setters, 2 Mallets, 2 Fuze saws — 1 spare.
$\frac{1}{3}$ Fuze extractors.
1 Basket.
1 Broom.
1 Tarpaulin.

The implements for *shells* are not required for the stone mortar.

For each Casemate Carriage (including the Spare Carriages).—2 traversing handspikes—2 truck handspikes—1 quoin, or elevating machine—4 chocks, 2 spare—1 broom.

For each Barbette Carriage.—4 manœuvring handspikes, 2 spare—1 tarpaulin or other cover—1 platform and 2 mauls; if the platform is not permanent.

For each Siege Carriage.—4 handspikes, 2 spare—2 mauls—1 platform.

Spare Parts for Repair of Carriages.

Proportion of the number of spare parts to that of similar parts which belong to the carriages.

Forks for traversing wheels of barbette carriages		$\frac{1}{20}$th
Pintles for siege carriage limbers		$\frac{1}{30}$th
Pintles for casemate carriages		$\frac{1}{20}$th
Linchpins		$\frac{1}{5}$th
Axletrees	for siege carriages	$\frac{1}{20}$th
	for barbette carriages	$\frac{1}{40}$th
	for casemate carriages	$\frac{1}{40}$th
Rollers for casemate carriages		$\frac{1}{40}$th
Bolster-plates for pintles not permanently fixed		$\frac{1}{40}$th
Wheels	for siege carriages	$\frac{1}{15}$th
	for barbette upper carriages (including rollers)	$\frac{1}{20}$th
	for casemate carriages	$\frac{1}{40}$th
	for barbette chassis	$\frac{1}{40}$th
	for casemate chassis	$\frac{1}{40}$th
Axle-washers,	shoulder	$\frac{1}{20}$th
	linch	$\frac{1}{10}$th
Poles for siege carriage limbers, one-half ironed		$\frac{1}{4}$th
Elevating screws		$\frac{1}{8}$th
Double trees for siege carriages, one-half ironed		$\frac{1}{4}$th
Tongues (iron) for casemate carriages		$\frac{1}{10}$th
Nuts, assorted		$\frac{1}{10}$th

Timber, and other Material, for Repairs.

Cheeks, stocks, naves, spokes, felloes, for siege carriages; of each $\frac{1}{20}$th—cheeks of mortar-beds, $\frac{1}{12}$th—handspikes, 4 to a piece—tool-handles, $\frac{1}{2}$—sets of timber for barbette carriages, $\frac{1}{20}$th—ditto casemate, $\frac{1}{40}$th—iron, assorted, 50 lbs. to each piece—nails and screws, assorted, 100 to each piece—steel, 1 lb. to each piece—sheet iron, 6 square feet to each piece—tin, 5 sheets to each piece—spare parts for small arms.

Machines, Ropes, &c.

Gyns, casemate and rampart, as may be required, according to the extent of the fort—jack-screws—capstans—lever-jacks—wheel-barrows, 1 to each piece—hand-barrow, for shells, 1 to each mortar—sling hand-barrow, and frame hand-barrow with legs, 1 to each gun and howitzer—platform balance, or scales and weights—gyn falls, $\frac{1}{5}$th spare—double prolonges, 2 to each gyn—drag-ropes—trace-ropes—small rope, 5 lbs. to a piece.

Tools.

Sets of carriage-makers', smiths', and armourers' tools—intrenching and miners' tools—saws—levels—paviours' rammers—10-ft. rods—2-ft. rules: the number of each kind to be regulated by the particular circumstances of each case.

Tools and Materials for Fire-works, &c.

Laboratory tools and materials, according to the extent and resources of the fort: see the proportion of those for a siege train. For each night of a siege, or for each night on which the guns will probably be served, have six tarred links to each piece, mounted on the ramparts of a front of attack, or of a sea-coast battery, and five fire-balls for a front of attack; six carcasses for each large mortar on a front of attack.

Signal rockets, torches, fire-stone, &c., according to circumstances.

Instruments, Books, Stationery, &c.,

According to the character and extent of the fort.—See 'Siege Train.'

Miscellaneous Supplies.

Timber, plank, and boards—wood for sabots, fascines, gabions, &c.—pickets—coal, 5 tons to a forge—grease—grind-stones—rampart grates, 2 to each piece on the ramparts—sand-bags for the batteries of the front of attack—lanthorn, 1 to each piece—candles—oil—fire-engine and buckets.

Field-pieces, forming a part of the armament of a fortification, should be provided with their caissons, ammunition, &c., as for service in the field.

EQUIPMENT, MUSKET-BALL CARTRIDGE.

Musket-Ball Cartridge Equipment is important to every branch of the army, as regards an adequate supply and mode of conveyance. The several descriptions of musket-ball cartridge, and the mode of packing as adopted in the Laboratory at Woolwich, is explained in the Article 'Ammunition.'

In order to regulate the supply and mode of conveyance, and describe the equipment, it is necessary to give the proportion required for an army taking the field. The Committee of Artillery Officers at Woolwich recommended that it should not be less than five times the quantity carried by the soldier, *i. e.* supposing the army to be sixty thousand, $60,000 \times 60 \times 5 = 18,000,000$ ball cartridges necessary for six months' active operations. This quantity could be only supplied in certain proportions, according to the immediate wants of the army, by establishing entrepôts, as the whole would require 1000 waggons and about 3600 horses for small-arm ammunition alone.

Vide Plate, 'Musket-ball cartridge carriage.'

The waggon constructed for this equipment will carry 20,000 rounds, and is drawn by four horses: the wheels and axles are similar to the Ammunition Waggon, and it seems well adapted for the conveyance of musket-ball cartridges in any country where a field battery can move.

The supply of small-arm ammunition is usually afforded by organizing a certain number of waggons into equipments, in charge of detachments of Artillery; one equipment to each division of Infantry, a small proportion to Cavalry, and equipments in reserve in the following proportions:

Table of Musket-Ball Cartridge Equipments.

Nature.	Cavalry Division for 80,000 rounds.	Infantry Division for 240,000 rounds.	Reserve for three Divisions carrying 400,000 rounds.	Remarks.
Waggons.				
Musket-ball . . .	4	12	20	See Plate.
Forge	1	1	1	Ordinary forge waggon.
Store	1	2	3	Flanders waggon.
Total waggons . .	6	15	24	
Royal Artillery.				
Captain	..	1	1	
Lieutenants	1	2	3	
Surgeon	..	1	1	
Staff Serjeant . . .	..	1	1	
Serjeants	1	2	3	
Corporals	1	2	3	
Bombardiers . . .	2	4	6	
Buglers	1	2	2	
Gunners	18	36	54	
Drivers	12	30	48	
Farriers	..	1	1	
Shoeing Smith . . .	1	2	3	
Total	37	84	126	
Horses.				
Draught	24	60	96	
Saddle	3	6	9	
Baggage	1	4	5	
Total horses . . .	28	70	110	

For an army of 60,000 men, there will be consequently

Two Cavalry equipments }
Six Infantry ,, } 150 waggons,*
Two Reserve ,, }

conveying 2,680,000 ball cartridges, or about $\frac{1}{7}$th of the proportion allotted to this army at the commencement of a campaign. As this supply is expended, the equipments will return to the entrepôt to be replenished.

The supply for a siege operation is afforded usually by taking the waggons of the country for this purpose.

The Artillery Department has the organization and charge of the musket-ball cartridge equipments to an army moving in the field, but the responsibility of the proportions to be supplied should be with the Adjutant-General's Department, which alone is acquainted with the expenditure and wants of the army: this has hitherto been thrown on the Artillery. It would appear to suffice, if these last kept the equipments efficient, and the requisite supply at the entrepôts, leaving the extent of that supply to be determined by the proper Department.

A musket-ball equipment, composed of two-wheeled carts, and drawn by two horses, has been used, and this equipment supplied the British army at Waterloo, and

* Including forge and store waggons, as above detailed.

is now (1845) used in Ireland, and seems only adapted to limited operations, in advance.

The comparative utility of two and four-wheeled waggons has been well compared and discussed, and apparently finally settled in favor of the latter, by the Committee of Artillery Officers, whose opinions are too valuable, on this and all other equipments, to be passed over, and are given in the following extract:

"*Conveyance of Small-Arm Ammunition.*—The usual means of conveying small-arm ammunition in the British Service has hitherto been the musket-ball cartridge cart, holding 12,000 rounds, drawn by two horses: during the Waterloo campaign, however, only 10,000 rounds were carried in the cart, as that quantity was deemed a sufficient load, but this, in common slow movements even, was found too much for a pair of horses, far less could they be expected therefore to move at an accelerated rate when such was necessary.

"In the Peninsula, when it was an object to take forward as great a quantity of ammunition as possible, the carts carried the whole 12,000 rounds; but to insure its getting on there was a necessity for its being drawn by four horses, and the same would have been necessary in France, on account of the deepness of the cross roads, had the cart been loaded to its full extent.

"From the above, therefore, it appears that the present ball-cartridge cart, with the reduced load, is too much for a pair, and that it will contain too little ammunition for four horses.

"To remedy this inconvenience, therefore, the Committee are of opinion that four-wheeled carriages for small-arm ammunition would be far preferable to carts, and would afford the power of a better application of physical force for their movements.

"The Committee have to shew, that although in their arrangement of field equipment the small-arm ammunition limber waggons are proposed for 24,000 rounds, to move with four horses, it is not without having adverted to the increased weight of the carriages thus loaded beyond the ammunition carriages, which would render a diminution of ammunition necessary in the event of a difficult country; at the same time it is deemed advisable that the waggon should be able to contain 20,000 rounds, in case the scene of operations admitted a facility of movement. There would, as circumstances varied, therefore, be the power of regulating the movement of small-arm ammunition as follows. In a good country, and the summer season, the waggon might move with 20,000 rounds, drawn by four horses; but in a difficult country, or a procrastinated campaign, the same load would require an additional pair of horses, and under any circumstances the service might be continued with four horses, by diminishing the load of the waggon to 16,000 rounds, which its construction would admit of without danger of injuring the ammunition.

"Another considerable advantage would be obtained also by the waggon being fitted for 20,000 rounds: it would afford the means of bringing forward the greatest possible quantity from the dépôts, and also moving forward a greater proportion to points of assembly preparatory to battles, or supply of advanced reserves, and which, in many instances, would admit of waggons being sent sooner to the rear for more ammunition.

"It may be argued in favor of two-wheeled carriages, that they would be more easy to conduct up great steeps, or extricate from difficulties; but reverting to the experience in Portugal, it may be considered as quite conclusive that a four-wheeled carriage, fairly horsed, like our ammunition limber waggon, can be conducted over every species of country where there is any thing like a carriage-road; and, on the other hand, the carriages with four wheels would possess the following important advantages over those with two.

"There would be less wear and tear of horses than with carts when all work in shafts, and consequently fewer spare horses would be required with waggon reserves.

"Carts would require to have all large, or what is termed wheel horses, whereas a mixed description of horse would be available for waggons to be distributed for wheel and leading, as is practised with batteries of artillery.

"Should it be required to detach ammunition with great expedition from a waggon reserve, towards any given point, it might be done by taking the leading horses from half the waggons, and advancing the other half rapidly with six horses, or by unlimbering and sending the limbers alone with four horses; and this is an advantage which carts would not admit of, for want of leading harness. The horses with waggons would be more ready to render mutual assistance to the carriages in difficulty than those with carts.

"In case of retreat and being pressed by an enemy, should the horses be hard worked and the roads very bad, considerable casualties would naturally be the consequence, which would occasion many carts being lost or destroyed; for it would be impossible for a cart to proceed with one horse, though a waggon could do with three; that is to say, if a reserve of twelve waggons was reduced to thirty-six horses, it would still continue to move without diminution of carriage, whereas a reserve of twenty-four carts, under similar circumstances, would be obliged to abandon six carts; besides, in the time of march, should a horse drop in a waggon, it would be easily extricated, and the waggon move on, whilst, by the same thing occurring with a cart, if a spare horse was not at hand, the movement of the column would be either interrupted, or the cart thrown out of the road."

Note.—By a recent arrangement in the French Service, the musket-ball ammunition equipments are associated with the field batteries attached to divisions of Infantry.

ESCALADE.*

This Article will comprehend three subjects.

1. The Means of effecting this operation, *i. e.* the Scaling Ladder.
2. The Arrangement before escalading works.
3. The Execution.

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1. *There are two kinds of Scaling Ladder*, those in lengths, provided by Government with other Engineer stores, which have never yet been used,—and those of an impromptu kind, made for the occasion: the first description (used in the School of Instruction of Chatham) consists of ladders about 12 feet in length, which fit into one another, so that each joint will give an effective length of 10 feet: they are made tapering, as explained in the annexed figures.

Fig. 1.

* Compiled by Colonel Lewis, C.B. R.E.

PLAN AND ELEVATION
of a
MUSKET BALL CARTRIDGE WAGGON
CONTAINING 20,000 ROUNDS

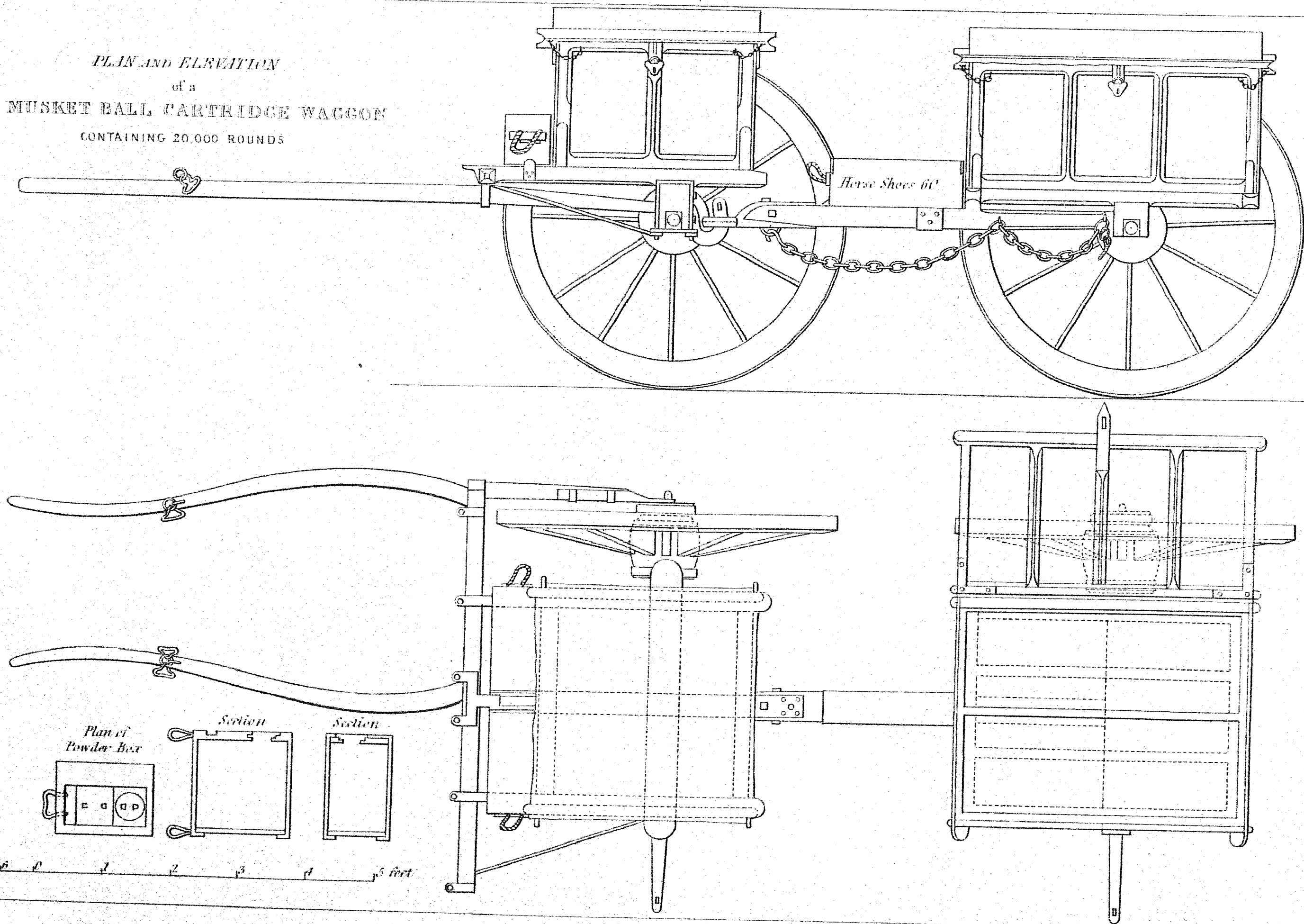
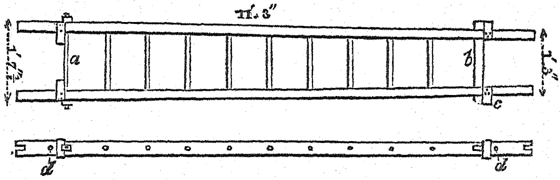


Fig. 2.



Sides 3¾" deep by 2" thick.—Yellow pine.

a. Iron rung of ¾" round iron.
b. Broad wooden rung: this and all except *a* are of oak.
c. Iron bands receiving the ends of the next ladder when fitted as in fig. 1.
d. Lashing-holes.
Weight about 50 lbs.

One length of Major-General Pasley's ladder consists of two of the above joints and a half joint or short ladder 7′ 6″ in length, with the same widths at top and bottom, as given in fig. 2.

The sides of the ladder to be of good yellow pine; all the rungs of oak except *a*, which is of ¾″ bolt iron. The clasps *b* to be of 2½″ × ⅜″ flat iron.

The old regular pattern ladders, previous to the Peninsular War, were in lengths of 6 feet, very heavy, and when five or six were put together they broke down with their own weight: those used at Chatham are found to answer, and are extremely serviceable in practice, after having been brought to the most perfect state by various trials by Major-General Pasley, at Chatham; they will likewise be found very convenient in the transport.

The second description of ladder in one length, such as those by which the escalade at Badajos and other places was effected, are made of light but strong wood; those in common use in building are of one spar sawn in two, wooden rungs, with iron rods under them, at about every 10 feet apart, and are easily made by any carpenter when suitable timber can be had: Upher poles are most esteemed in England. In the campaign in Affghanistan the bamboo was used, according to Lieut. Durand.* In experiments made at Chatham it was, however, found that these canes could not be bored without weakening them too much: the ladder, therefore, consisted of the two side pieces, and of rungs lashed across instead of passing through them.

These ladders in one length are extremely difficult of carriage, for which reason waggons are constructed on purpose; and in mountain and bad roads, owing to the great length of the ladder, they are unfit for transport. However, as they may be required again under similar circumstances, an account of them is here given.

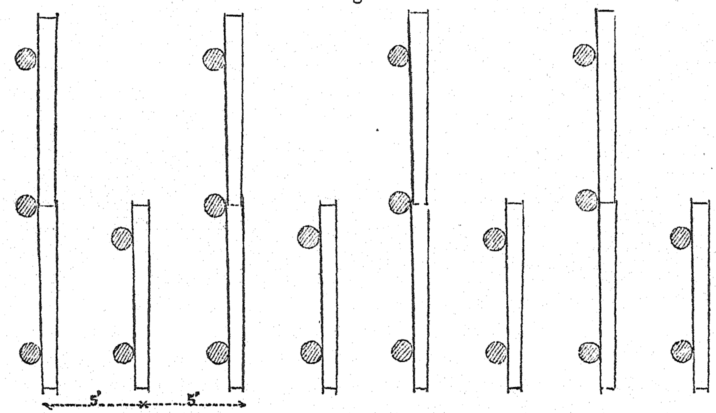
2. *The Arrangement for an Escalade.*—The arrangement for the transport of the ladder is a previous question, depending upon the description used, and is more appropriately considered under the head of 'Equipment.' It is presumed that they are carried to the spot by the Engineer Department, when the party intended for the escalade is to meet, unseen, and under cover if possible, 600 or 700 yards from work to be attacked. It is necessary, in order to be clear, to imagine the operation to be performed *either* by ladders in lengths or ladders entire: for the first, the arrangements taught at Chatham will be the data; and for the latter, those proposed by Major Jebb, in his 'Practical Treatise.'

Ladders in lengths.—It will be found convenient to fix them in double lengths, and single, alternately, as it is not possible to imagine any work to be escaladed less than

* Corps Papers, vols. iv. and vi.

10 feet in height: the double lengths are made fast with the lashing usually fixed to the ladders, so that in lowering them down to descend a counterscarp they will not separate; they will be, therefore, spread on the ground, as explained below, in alternate double and single ladders, in reference to the work to be escaladed, and in rows, as may be best suited to the place of deposit, with the broad end to the front, at 4 or 5 feet apart.

Fig. 3.



There will be required, therefore, two men to each length.

Ladders entire will be arranged at 4 or 5 feet apart, and will require six men to each ladder to carry them to the escalade: diagrams 4 to 9 will serve to explain the arrangement on the ground.

3. *The Arrangements for the Execution of an Escalade.*—The attack of works by escalade may be conceived the reverse of other assaults, being performed in open order instead of close when approaching the place (for the *general* operations of an assault, see Article 'Assault' of the Aide-Mémoire): for the special operation the following suggestions are given, observing that it is immaterial whether there is a counterscarp or not, except that a greater number of ladders are required, and the operation will be described with *Ladders in lengths*, or with *Ladders entire*. Supposing in the former the number of 10-feet joints available to be 180, and in the latter (entire) 60; the assaulting party will be supposed to consist, in both cases, of 400 men, with a supporting party of the same strength; the height of the escarps having been ascertained pretty accurately:* observing that if there is a counterscarp, the ladders must be left there until the assault is over, which is sometimes omitted in instructions given, and which prevents the support following, and also renders a retreat impracticable. In all cases when there is a counterscarp, or that it is not very low, one-third of the ladders should remain there, and consequently an adequate provision thought of: hence it will be seen that the ladders in lengths are most convenient, as there will be no waste of material, which must be the case when they are entire, of 30 feet long, appearing an unnecessary height above the counterscarp, which would be the case were the ditch only 12 feet deep: leaving, therefore, a proportion of single ladders on a counterscarp, the party with the double ones will fix them on the escarp, raising them from below, if not of sufficient height, to fix one or more lengths as may be;

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* By the Engineer preparatory to the escalade.

10 to 18 feet requiring 2 lengths,
18 to 28 „ „ 3 „
28 to 35 „ „ 4 „

but if possible the ladder should over-reach the height of the escarp 3 feet, to assist to get a foot on the rampart or wall.

The Escalade by Ladders in lengths.—These are now supposed to be arranged on the ground. The attacking party will be divided into—one-half as the covering party, to extend themselves with their bellies on the ground, on the crest of the glacis, to keep under the fire as much as possible,—the other half to be formed into sections of five, with arms and accoutrements, but the slings slacked. Reverting to fig. 3, each party of five will move between the alternate short and long lengths, consisting of 60 of two lengths, and 60 of one length, three men taking the long one, and two the other, on their right shoulders, having previously slung the musket (bayonet unfixed) over their left. On the word 'forward' the party will move onward, preceded by the Engineers, assisted by a detachment of Sappers, provided with axes and crowbars, to the point of attack, between the files of the covering party. On reaching the *escarp* (the descent into the ditch being explained and provided for if there is a counterscarp) the threes with the double ladder will rear it by planting the butt end firmly on the ground; and conceiving, by way of example, the *escarp* or exterior revetment to be above 18 feet in height, the third ladder will be used by raising the double one and fixing the other below: this method will not be difficult, by extending the bottom of the first as far as possible from the wall, and then hoisting up all three: an escalade above 25 or 28 feet is rarely practicable except by surprise.* When the ladders are thus raised, the men will fix bayonets, carrying their muskets slung on their left arms, for the purpose of having a good hold of the ladder until near the top: those who precede should be provided with a sap-hook, to secure a good footing on the parapet, and the sap-hook is not a bad weapon if a personal encounter does occur: thus fixed, the advanced men of each ladder can give great assistance to those who follow.

The Escalade by Ladders entire.—This operation being preceded by the ladders being arranged similar to what is described in figs. 4 to 9,—the attacking party, as before, divided into two, one-half the covering party,—the other will be divided into sections of six, and move between the spaces of the sixty long or entire ladders, of about 30 feet in length;—when so posted, on the word 'forward,' with the arms slung, they will proceed to the attack: if there is a counterscarp, the whole of the ladders will be placed to descend, and when in the ditch two-thirds or forty will be carried forward butt on, according to Major Jebb (in figs. 9 to 12), and raised against the escarp or exterior revetment, bayonets now fixed, and the escalade attempted, as before explained, the leading men of each ladder being provided with a sap-hook. It will be seen with these long ladders, that there is much difficulty in turning them over, particularly under fire, as they must be spread over very much of the breadth of the ditch.† But all escalades, to be successful, must be a sort of sur-

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* Vauban considered 36 feet French, or 38 feet 4 inches English, to be beyond escalade.

† "All the ladders used this night ‡ were the ordinary ladders of the English mechanics, and were made during the course of the siege. There were twelve supplied for this escalade, and the same number for General Leith's. They were called 30-feet ladders, but some of the longest measured 32 feet, and three or four not more than 28 feet.

"The experience of all the escalades in the Peninsula leads to the belief that such description of

‡ Storming of Badajos.

prise, as against a garrison taken unawares, or otherwise occupied in a real or a false attack: they should be apparently desultory, and at various places, and moreover well supported by a reserve.

This operation is given by Major Jebb in fuller detail, as follows:

"We have three companies in line, and we wish to carry the ladders forward, so that the front rank of the centre company shall be placed in a position to ascend the ladders first, and afterwards to stand at the head of a double column of subdivisions formed upon it,—we will say 20 yards in front of where the ladders are placed. The ladders are supposed to be laid out all ready on the ground, in front of the line, fig. 4. The cautions and words of command might be as follows.

"Form quarter distance column, in rear of the two centre subdivisions. See fig. 5.	According to regulation.
"By files extend from the centre and cover the ladders. "Outwards face—or Outwards close—Quick march.	The corresponding files of the 3 subdivisions would halt and cover the ladders in succession; the ladders and files having been previously numbered from centre to flanks.

Fig. 4.

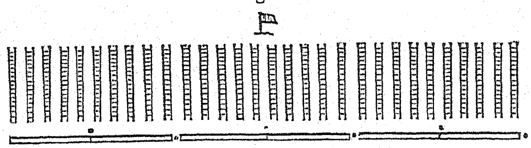
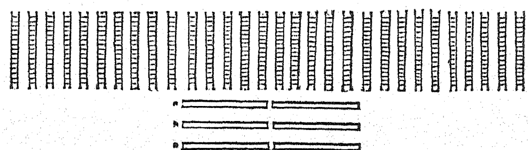
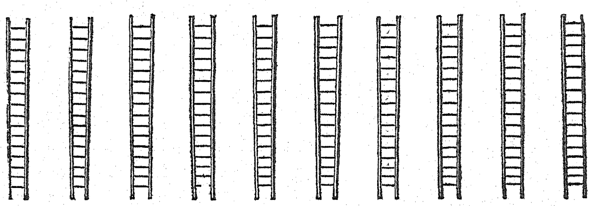


Fig. 5.





ladder is the best that can be used. The greatest difficulty experienced was to bring such unwieldy machines to the spot; but once there, they were raised readily enough, when not seriously opposed.

"Had the jointed scaling ladders, supplied as an Engineer store,* been sufficiently strong for the purposes of an escalade, they could not have been put together under the fire and missiles poured down on the assailants from the parapet on these occasions; and should any more perfect jointed ladders be substituted, it will always be found necessary to put them together before the garrison discover the party.

"These unwieldy ladders travelled on cars many marches with the army, but they are so readily

* The old pattern alluded to in the beginning of this Article, not those of Major-General Pasley.

"The files would then be in the position shewn in fig. 6, and the rear rank men would merely have to step up into the same alignment as the front rank, instead of covering

Fig. 6.

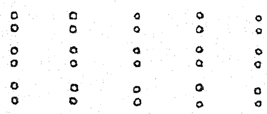
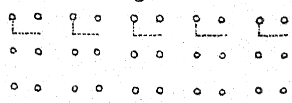
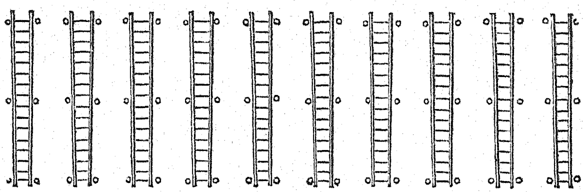


Fig. 7.



them (as shewn in fig. 7), and then being moved forward and filed between the ladders (fig. 8), they would be ready to advance with them in line; and by preserving

Fig. 8.

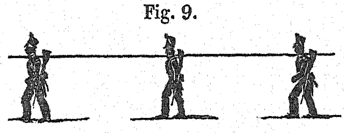


the order in which they then stood, or something like it, in ascending out of the ditch, they would be in their places for re-forming the double column again, in the situation required.

"It may be said, this is all very fine and regular, but how is such order to be preserved under a heavy and destructive fire? We answer,—the greater the probability of confusion, the greater is the necessity of taking every possible precaution to lessen the chance of it, and obviate its effects. It is not pretended that in the heat of action men could exactly keep their places,—the impetuosity and keenness of the many, and the *caution* of the few, would of itself prevent it,—but every man would be in his *right place*, when at the bottom of the ditch, for securing this formation; and they could not well be much out of it, in a compact column of three companies,—formed within so limited a distance to their front.

"This explanatory digression being ended, we must revert to where it commenced, and suppose the two lines of ladders are laid out, and that the men disposed on the above system are in readiness to take them up. The most convenient way of carrying ladders is on the shoulder (fig. 9); when therefore they were thus raised, the line

Fig. 9.



made when required, that it can seldom be worth the trouble of removing them from place to place. Their weight and strength were considered great advantages when once raised, as there were many hard struggles between those above to throw over, and those below to support the ladders, which would have broken less solid machines.

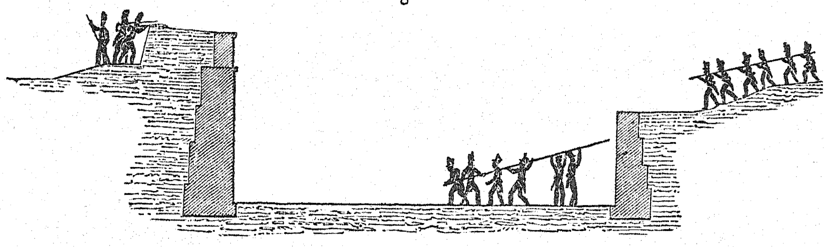
"It is believed, that the honour of raising and forcing up the first ladder, on this occasion, attaches to Lieut.-Colonel Ridge, in command of the 5th regiment, who met his fate on the castle wall."—*Jones's 'Sieges,' Note* 21, *third edition.*

would be in readiness to advance, and in as close order as is practicable, which it may be observed, *en passant*, is a point to be attended to.

"The firing party would precede the ladders, and act according to circumstances, the object being to keep down the fire from the parapets or embrasures,—to prevent the enemy shewing himself, or making any attempt to throw the ladders back,—or in any way to arrogate to himself the right of assuming the offensive, outside the parapet: any such attempt should be regarded as a decided case of trespass, and should be dealt with accordingly.

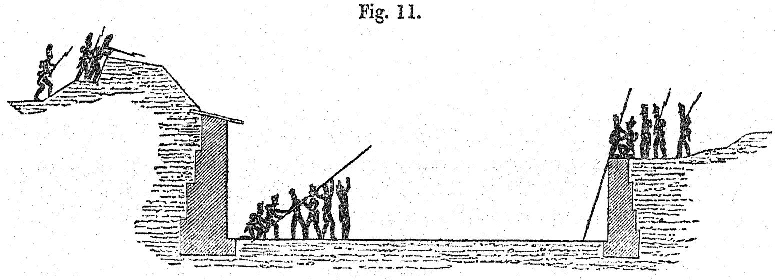
"The leading division, on arriving at the spot, would lower the ladders into the ditch (fig. 10), and the men would immediately descend, and when they were all down

Fig. 10.



would instantly shift them over to the opposite side, planting the foot of each ladder against the bottom of the scarp, and then turning the top over (fig. 11), the foot being

Fig. 11.



afterwards dragged away from the wall about one pace, to give it a little inclination; but the less it has the better, for the more upright, the stronger it will be; and it is also easier for the men to ascend than when there is much slope. The moment the first division of ladders were out of the way, the second would be lowered into the place from which they had been removed (fig. 11), and the men carrying them would in like manner descend; but those ladders would not be shifted across the ditch, but left where they were first lowered, and thus a complete communication would be established, by which the remainder of the storming party, and the support, could follow in close succession.

"With a still more scanty supply of ladders, or with greater means of resistance to be overcome,—in fact where it would be very desirable to have the *whole* of the disposable ladders reared against the scarp for making the attack,—we must not be deterred from the attempt by apparent difficulties. Send them all on in one line if it *must* be so, carried by six men. Let another division of men descend before they are shifted across the ditch, and let the support jump down upon bags of hay, as they did at Badajos! Throwing a force into confusion, and letting men roll one over the

other, will signify nothing in an escalade, in comparison of the evil effects which result from breaking the ranks of a close column on the eve of rushing forward to assault a breach; *that* is to be avoided by every possible means. But with respect to an escalade, there will always be delay at the foot of the ladders; and if men get there at the time there is room for them to ascend, it is quite sufficient, and we need not be too particular as to their coming up in very regular order."

When an enterprise of this nature is contemplated, in most cases it is possible to practise the Sappers and men of the several regiments in escalading, and thus render the operation easy, or at least one without confusion; and as the material, *i.e.* either the long or short ladder, must have been provided, the instruction might be given with little trouble.

This Article will be concluded by the following from Jones's 'Sieges,' rightly quoted by Major Jebb as a brilliant example of daring and successful enterprise.

DESCRIPTION OF THE WORKS.

"The works at that place (Almaraz) had been constructed with great expense and labour, by the French, under the view of securing their communication across the Tagus, on both banks. On the right of the river they consisted of a redoubt for 400 men, on a very respectable profile, called Fort Ragusa, with a masonry tower in the interior 25 feet high, having two rows of loopholes for musketry.

"This work being situated so far from the bank of the river as to admit of the possibility of an attempt being made in the night to destroy the bridge in its rear, a flèche had been constructed on the river bank, which also served to flank Fort Ragusa.

"On the left bank, a well-flanked tête-de-pont, revetted with masonry on a good profile, secured the bridge; and as the ground rose immediately from the river to some heights which commanded the tête-de-pont at a short distance, a redoubt for 450 men had been constructed on their summit. This work, called Fort Napoleon, had a retrenchment across its rear, supported by a loopholed tower in its centre, 25 feet in height.

RECONNOISSANCE.

"18*th May*.—This morning, Lieutenant Wright, of the Engineers, was sent out to gain all the information possible respecting the works, and the ground around them; whilst the Artillery Officers should renew their search for an opening to get their guns forward. The result of these examinations taking away all hope of forcing the Pass of Miravete, or of finding any other passage over the ridge practicable for artillery, the enterprise must have been abandoned, without some extraordinary decision on the part of its Commander. Happily that was not wanting, as will be seen below.

MOVEMENTS OF THE ESCALADE.

"At 9 P.M. the troops began to descend the Sierra, and the head of the column arrived in the vicinity of Fort Napoleon at daybreak; but from the difficulties of the road, although the distance from La Cueva did not exceed five or six miles, a considerable period elapsed before the rear closed up. Luckily, however, some intervening hills admitted of the head of the column being kept concealed from the garrison, at about 800 yards distant; and the troops remained undiscovered till completely formed. Soon after daylight, as had been concerted, under the expectation that it would be almost a simultaneous effort with the escalade of the forts, General Chowne made a false attack upon Miravete, and the 24-pounder howitzers commenced a distant fire of round shot and spherical case against the castle. This firing naturally attracted the attention of the garrison of Fort Napoleon, and put them on the alert. They

mounted on the parapet, and watched with earnest curiosity the defensive efforts of their comrades in Miravete, but did not seem to have the slightest suspicion of the blow about to be struck against themselves.

"About 8 A. M. the rear of the descending column having closed up, the 50th regiment, and one wing of the 71st, moved forward to the assault of Fort Napoleon, regardless of a brisk fire that opened on them, as soon as discovered. They descended into the ditch of the outer work, at three points, and immediately reared the ladders; but from the great breadth of the berm the ladders could not be made to rest against the parapet. Each party, however, without being dismayed or confused, immediately ascended to the berm, and took footing upon it; then drew up the ladders, fixed them on the berm as a second operation, and almost simultaneously mounted the parapet, against a vigorous resistance.

"As soon as fifteen or twenty men were on the top of the parapet, the defenders of the exterior line gave way, and made for the communication to the retrenchment. This was by a narrow door-way, through a small building covered by the parapet of the outer line, from which a narrow bridge led to the inner defence, and seemed to render it secure; but the assailants followed the garrison so quickly, that they entered the door-way together, and a sharp but momentary contest took place, in which the French commandant was wounded and made prisoner. Overpowering numbers of the troops having now escaladed the fort, the garrison abandoned the retrenchment and the tower, and fled in the greatest confusion to the tête-de-pont, the assailants pursuing them so closely, that both parties pushed together into that work, when all resistance ceased.

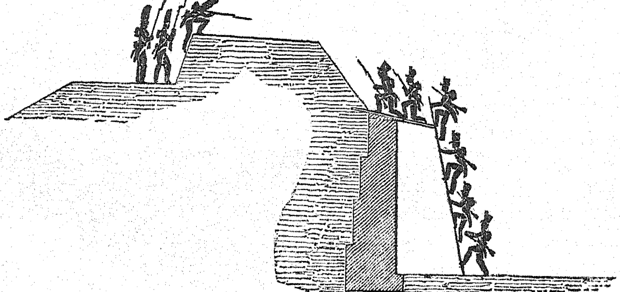
"The flying enemy crowded on the bridge to escape across the river, but those first over cut away three of the boats, in consequence of which a number of men and officers leaped into the river and were drowned, and the remainder, above 250, were made prisoners.

"The garrison of Fort Ragusa, seeing what had happened, opened a fire of artillery against Fort Napoleon, but Lieut. Love most promptly turned the guns of Napoleon against Ragusa, and after he had fired a few rounds, the French garrison evacuated the fort, made a hasty formation at the foot of the glacis, and then marched off towards Naval Moral.

"The reduction of these formidable works was thus effected by means of the musket and bayonet alone, and with the loss of only 2 officers and 31 men killed, and 13 officers and 131 men wounded."

"This is a history of what has been done with a scanty supply of ladders; when, therefore, we have 'impossible things' of this sort to accomplish, let us recollect what Hill did at Almaraz,—Picton and Kempt at the castle of Badajos,—Leith and Walker at the Bastion St. Vincente."

Fig. 12.



Vide Note 1.

EVOLUTIONS OF INFANTRY.*

"Troops are taught to execute every movement that can be required of them: the application of these movements can only be determined on the spot, according to the nature of the country, and the strength and dispositions of the enemy."—*Field Exercise and Evolutions of the Army*, Part IV. Sec. 8.

Vide 'Field Exercises,' Part IV. Sec. 3.

The ultimate object of tactical organization and movements may be defined to be *the formation of the line of battle by the shortest possible methods in any given direction and position.*

In investigating the methods by which this object is attained, it will be expedient, for the purpose of simplifying the inquiry, and of more clearly elucidating the principles involved in it, to consider the tactical constitution of infantry in the abstract; to view it merely as a means for effecting the movements of masses of men, without any reference to the application of these movements to the circumstances of war.

No reference will, therefore, be made to the objects which particular movements are calculated to effect, nor will any allusion be made to the combination of the action of infantry with that of cavalry and artillery.

The Tactical Constitution of Infantry involves three considerations—viz., its *Formation*, *Composition*, and *Evolutions.*

The points, then, to be considered are,

First. What is the primary formation, or order, most suitable for infantry.

Second. What is the composition best adapted for effecting the movement of masses developed according to this formation.

Third. What evolutions are necessary for effecting changes in the order, position, and direction of the primary formation.

FORMATIONS.

"Mais laquelle sera l'ordonnance primitive et habituelle? L'ordonnance de feu, ou celle de choc?

"C'est une question qui merite d'être discutée avec quelques détails, et examinée avec l'attention la plus réfléchie; j'ignore l'art d'être clair pour qui ne veut pas être attentif.

"La multiplicité de l'artillerie, la science du choix des postes, celle des retranchemens ont rendu aujourd'hui les actions de choc infiniment rares; donc celles de feu étant plus communes, c'est une raison de plus pour que l'ordonnance propre au feu soit l'ordonnance primitive et habituelle."—*Guibert, Essai Général de Tactique. Tactique de l'Infanterie*, chap. I.

When a mass of men encounters an opposing force, it should be so arrayed that the efforts of every individual may be available for the destruction of the enemy, and that these efforts may be as much concentrated as possible.

It follows, therefore, that the order in which a body of troops should be formed ought to be determined by a consideration of the nature of the arms and modes of offence used in the existing system of warfare.

In ancient times battles were chiefly decided by the personal encounter of the combatants, and the power of infantry consisted in the vigour and unity of its shock.

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* By Captain Robertson, 8th Regiment.

Masses of pikemen, like the Macedonian phalanx, or single ranks of swordsmen, like the Roman cohorts, were formations well adapted for this mode of fighting.

At the present day the collision of large bodies of infantry is a spectacle which is seldom witnessed; positions are assailed and defended by showers of bullets; the vigour of an attack is measured by the force, number, and precision of the projectiles directed on the point assailed; and battles are won less by the exertion of superior strength than by the relative position of the antagonists and the pertinacity of more obstinate endurance.

The power of modern infantry, therefore, principally consists in the quantity and precision of its fire; and its formation ought to be so determined as to render the fire of the line as effective as possible.

To attain this object, the order of formation should fulfil the following conditions:

First. The effect of the fire of a body of troops should always be in proportion, or nearly in proportion, to its force.

Second. Its fire should be as much concentrated as is consistent with the above condition.

Hence it follows that, provided the fire of every individual composing it can be rendered effective, the closer and deeper a body of infantry is formed, the more formidable it will be.

The nature of modern warfare seems to require that the formation of infantry should be in accordance with these principles, and that, by reference to them, should be determined the number of ranks of which the line of battle should consist.

The practice of European armies, however, differs on this fundamental tactical point, and the opinions of tacticians are divided as to whether infantry should be formed in double or treble ranks.

In order to come to a just conclusion respecting the relative merits of these two formations, it would be necessary to ascertain satisfactorily, if the fire of a line of three ranks is more effective than the fire of a line of two ranks, nearly in the proportion of the strength of the lines, that is, nearly in the proportion of three to two, the extent of front of both lines being the same.

This could be easily ascertained, provided the results of target practice might be considered as a true indication of what takes place in the field; and, however much such results might differ from those which would be exhibited were it possible to obtain an accurate state of the casualties resulting from the actual encounter of a double and a treble line, yet the results of target practice, if collected from careful, extensive, and judicious experiments, could not fail to be valuable, as representing what takes place under certain normal conditions, and therefore constituting a basis of comparison which might be afterwards modified by statistical observations of the casualties of battles.

It may, indeed, be alleged that the question has been decided by the experience of late wars. But though these wars present numerous instances of British troops formed two-deep successfully contending with the three-deep formations of continental armies, it would be scarcely logical to draw from these instances any abstract conclusion respecting the merits of the two formations.

The successes and achievements of a double line of British soldiers are very far from proving that a treble line of the same soldiers would not be even more formidable to an enemy.*

* Whether this be true or not, the facility of occupying an extent of ground must not be forgotten; and on the decision as to whether ranks are to be three-deep or not will depend whether the line is to be reduced to two-thirds of its present length or not. *Vide*, however, Note 2.—*Ed.*

The following passages are extracted from the translation of the Duke of Ragusa's recent work, which appeared in the 'United Service Journal' for February, 1845.

They contain the decidedly expressed opinion of a great and experienced soldier in favor of the two-deep formation.

"Nothing can be said in favor of a third rank, for, without entering into a detail of volleys, persons of experience know that if one can at a review fire a volley in three ranks, it is impossible in war.

"It is ascertained to be impracticable to hand over the firelock to the third rank, as the French order prescribes.

"This method, being merely theoretical, is by no means applicable to the face of an enemy.

"In fact, the third rank, of its own accord, in a few moments forms into the other two; the most advantageous formation is, therefore, instinctively adopted; but as the change is made contrary to order, there results from it a kind of disorganization.

Vide Note 2.

"It is better, therefore, to adopt the two-deep formation, and to render it permanent."

The fact on which Marmont rests his opinion is, perhaps, of itself scarcely sufficient to justify an absolute conclusion, since it by no means necessarily follows that the most natural formation should be the most advantageous.

Marmont's testimony, however, most clearly proves that if not altogether impracticable, it is at least extremely difficult to bring the fire of a treble line of infantry to bear on an enemy, and that the treble formation, if suitable at all, is only so for veteran and highly disciplined troops.*

COMPOSITION.

"Comment faire marcher une ligne mince et flottante?

"Le voici; c'est en divisant une troupe nombreuse en plusieurs parties qu'on peut parvenir à la mouvoir avec facilité. Ce sont ces divisions, connues de tout temps dans la tactique qu'on appelle 'régiment,' 'bataillon,' 'escadron,' 'compagnie,' 'division,' &c. Cherchons à établir quelles doivent être leurs proportions."—*Guibert, Essai Général de Tactique. Tactique de l'Infanterie*, chap. I.

To effect any change in the formation or position of an extensive line, it is necessary to divide it into sections of a manageable size, and by a combination of the movements of these sections, to accomplish the required change.

The object of this composition is to secure facility and regularity of movement; but it must be remembered that the splitting of a mass into parts has a tendency to impair the vigour and unity of its action. Care ought, therefore, to be taken not to carry the process to a greater extent than is absolutely necessary to provide for facility of movement.

The Battalion.

The most important of tactical divisions is the Battalion; it corresponds to the cohort of the ancients, and may be considered as the unit of the modern tactical system.

The characteristic feature of this division, on which its utility depends, is its

* At the battle of Maida, the British Infantry were without their flank Companies which were formed into Flank Batallions; and the eight Companies of what may be termed the Line Battalions had a small portion of each Company told off into skirmishers, who retreated in the intervals made by the Officers stepping aside. These skirmishers, or Light Infantry, formed a third rank, and filled up the vacancies as they occurred.

The Infantry Battalions of the King's German Legion had no flank Companies, and were composed of eight Companies to each Battalion.

In the formation of Battalions one important point has been lost sight of in this discussion, that

capacity of receiving a simultaneous impulse from the word of command of its chief. Hence the strength of the human voice is the circumstance which ought to determine the limits of the strength of the Battalion.

The strength of the Battalion as it is actually constituted in our own and other European armies varies from 600 to 1000 men. The extent of its front in the two-deep formation is, therefore, from 233 to 388 yards.

An Officer placed near the centre of a line 600 strong can, under ordinary circumstances, without any great effort, make himself distinctly heard by every individual composing it; but the compass of the human voice is scarcely sufficient to direct the movements of a line of 1000 men formed two-deep. In armies, therefore, where this formation is adopted, the *effective* strength of a Battalion should never be allowed to exceed 700 or 800 men.*

Vide Note 3.

The Company.

The Company, or primary fraction of the Battalion, ranks next to it in importance. The principal things to be considered respecting it are—

1st. Its strength.

2nd. The aliquot relation it ought to bear to its whole.

1st. Strength of the Company.

The Company, which may be regarded as the ultimate and indivisible element of tactical organization, ought to possess the utmost flexibility and facility of movement, and ought at all times and under all circumstances to be able to change its position and direction without the order of its primary formation being altered or disturbed.

The principle mentioned as determining the constitution of the tactical unit, viz., *the capacity of receiving a direct impulse from the voice of its chief*, only involves one of the conditions on which depend the facility and flexibility of the movements of a military body.

To insure regularity and precision of movement, a simultaneous impulse must not only be given to the individuals composing the moving body, but the motion of each must be regulated so as to bear a certain definite relation to the general movement.

These individual rates of motion may be either equal or unequal, according to the nature of the movement; *e.g.* they are equal in line marching on level ground, and unequal in wheels.

Vide Note 4.

But whether equal or unequal, the difficulty of regulating them with precision is very great.

1st. On account of the diversity of the paces of the individuals themselves.

2nd. On account of the irregularity of the surface of the ground on which they must move; which irregularity produces a diversity in their facilities of motion.

It is, therefore, evident that, from the operation of these causes, as the numbers composing the moving body increase, the difficulty of preserving order in its movements increases in a compound ratio.

This difficulty, on tolerably even ground, may, to a great extent, be overcome by careful drilling; and there is no doubt that it is possible, under favorable circumstances, to manœuvre lines of very considerable extent without breaking them into parts.

Vide Note 5.

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there is this additional disadvantage of three-deep,—the greater liability to casualties, and that a gunshot will disable three men as easily as two.—*Editors*.

* The Battalion is unquestionably the Unit of Infantry, the Company the Fraction, and Brigade, Division, and Corps, the Multiple: this distinction in the composition of Armies is essential.

The strength of a Battalion must be regulated by the early probable casualties, of sick, and detachments; and if each Company enters a campaign 100 strong, it is probable that on no occasion will a Battalion exceed 800 in action. *Vide*, however, Note 2.—*Editors*.

But, taking into account the variety of ground in which troops must be capable of acting, and the difficulty of training men to a perfectly uniform rate of march, 50 files may be assumed as the maximum developement which ought to be given to the element (or the fraction)—a Company; and between 30 and 40 files a convenient strength for manœuvring.

Excepting on ground which is absolutely rugged, a line consisting of between 30 and 40 files ought to be able to march and to wheel without the order of its formation being materially deranged.

2nd. Number of Companies which ought to constitute the Battalion.

Symmetrical manœuvres, such as the formation of squares and of double columns, require that the Battalion should be always composed of an even number of Companies.

Whether it be composed of 4, 6, 8, or 10 Companies is a matter of no tactical importance; but when columns of the same strength manœuvre together in masses, it is desirable that the number of the divisions and the intervals between them should be so proportioned to the extent of their front that, in close column, the front should not exceed the depth of the column.—*Vide* 'Field Exercises,' Part IV. Sec. 4.

Vide Note 6.

Subdivisions of the Company.

Subdivisions, sections, and sections of threes, are useful in defiling, and in some manœuvres; but these minute subdivisions are so liable to derangement from casualties that they ought to be considered, not as primary and fundamental parts of military organization, but merely as secondary and occasional aids to facilitate the working of the system.

In defiling, it may be suggested, that it would be convenient to tell off the troops in sections corresponding to the breadth of the defile, without reference to the manner in which the Company is usually subdivided.

Divisions and Brigades.

It now remains to examine the constitution of masses consisting of the aggregation of several tactical units.

If it were attempted to determine the composition of a Division consisting of several Battalions according to a definite principle, then, by an extension of that used to determine the strength of the Battalion, the idea would naturally suggest itself of composing the Division of as many Battalions as the Battalion contains Companies.

The front of such a mass of Battalions formed in contiguous columns would not much exceed the front of a single Battalion deployed, and such a mass might, therefore, be manœuvred by the direct command of its chief with nearly the same facility as a single Battalion.

The constitution of the Divisions composing the Peninsular Army was similar to that here suggested, but it is not meant to be asserted that this constitution was determined by the analogy pointed out as subsisting between it and the constitution of the Battalion.

In the Duke of Wellington's army, the Division of ten Battalions was further organized in three Brigades, for the adoption of which subdivision the writer of this article is not aware that any purely tactical reason can be given.

Military organization, besides its tactical uses, is necessary to carry into effect administrative and logistic arrangements.

With reference to these arrangements, the classification of Battalions in divisions and brigades is of the greatest importance; but it is certainly erroneous to suppose that it is consistent with the usual practice of armies to adhere strictly to systematic analogies in the tactical arrangement and distribution of an army in the field, or to imagine that such precision, if attempted, would be suitable to the circumstances of war.

Vide Note 7.

When manœuvring in presence of an enemy, a General estimates his force accord-

ing to the number of Battalions of which it is composed; and, considering these Battalions as independent bodies, he combines them without regard to the preservation of the unity of brigades or divisions, in reserves and columns of attack, each consisting of a number of Battalions proportioned to the object it is intended to fulfil, and each liable to vary in its strength when circumstances require fresh combinations.

It is these Columns and Reserves, and not Divisions and Brigades, which constitute the real tactical divisions of an army.

A Reserve, consisting of a mass of several brigades, will frequently be estimated and employed by a General as a single quantity, while a detached Battalion, occupying an essential point, may sometimes enter into his calculations as a separate and important element.

EVOLUTIONS.*

"Il faut des évolutions, car sans évolution, une troupe ne serait qu'une masse sans mouvement, réduite à l'ordre primitif dans lequel on l'aurait placée, et incapable d'agir au premier changement de terrein ou des circonstances. Les évolutions sont donc les mouvemens par lesquels une troupe doit, relativement aux circonstances et au terrein, changer d'ordre et de situation.

"Elles doivent être simples, faciles, en petit nombre et relatives à la guerre."—*Guibert, Essai Général de Tactique. Tactique d'Infanterie*, chap. v.

If we examine the Evolutions prescribed in existing systems of Tactics, we shall find that it is not in all cases the simplest and shortest methods which have been chosen for effecting changes in the position and direction of the line of battle. In changes of front to the rear, for instance, a battalion does not simply face to the right about, but the change is effected by a tedious series of counter-marches.

In this and in other instances the most direct method of performing an evolution is abandoned, or greatly modified, for the purpose of preserving the relative position of the parts of the line in the order of their original formation.

Subjecting the formation of the line to the condition of the preservation of the parts of which it is composed in a certain fixed order has the disadvantage of complicating the theory of military movements, and occasionally of producing perplexity in their execution.

It would greatly increase the flexibility of military bodies if the utmost freedom of inversion were permitted; if the system of arbitrarily determining the front and rear, and the right and left flanks of a division, and of framing a system of manœuvres with reference to the preservation of these distinctions, were abandoned; and if, instead of permitting inversions as an exception, as is now the case, it were established as a general principle that the line should invariably be formed by the simplest and shortest possible process, without the least regard to which rank of a division might be placed in front, or which of its flanks on the right or left of the line.

As, however, this principle is not recognized otherwise than as an exception by any existing system of tactics, it is sufficient to suggest the possibility of its extended

* Lloyd observes that all Infantry Evolutions are but means of forming Line, or forming Column: to these may be added, in the British Service, the four-deep square; so that all *drill* may be carried on as a series of changes on the different elements,—Line, Column, Square,—Line, Square, Column, —Column, Line, Square, &c., &c., &c., whether referring to the Company, Battalion, or Brigade.—*Editors.*

application, without minutely discussing the probable effects of its adoption, or indicating the details by which it might be carried into execution.

In examining the different changes of position and direction of which the line is susceptible, those methods only of effecting these changes will, therefore, be noticed which are in accordance with the systems of tactics at present established in European armies, *i. e.* those systems based on the principle, *that in all formations the relative position of the portions of the line shall be preserved unchanged.*

EVOLUTIONS OF THE BATTALION.

The Evolutions of the Battalion are executed by means of combinations of the facings, marchings, and wheelings of the companies of which it is composed.

The Facings require no explanation.

Some observations on Marching will be found under that head.

Wheeling.

Concerning Wheeling, it may be remarked that, in changing the direction of a column on the march by the successive wheel of its divisions, there necessarily results a loss of time proportioned to the strength of the division, and to the angle of the wheel; and that in certain manœuvres, such as retiring in double column from both flanks in rear of the centre, the nature of the wheel also involves a loss of distance. To avoid these two inconveniences of loss of time and loss of distance, the French in some cases employ the following method of changing the direction of a column on the march.

Supposing right in front, and the change to be to the left, as each division approaches the point where the change of direction is to take place, it receives the caution, "*tournez à gauche,*" and on reaching the point, the word "*marche:*" at this word the *guide* (or pivot-man) immediately turns into the new direction, and continues his march, without altering either the length or cadence of his step; the other men, lengthening their pace, and bringing their shoulders forward, gradually align themselves on the guide, each man, as he gains the alignment, resuming his former step and rate of march, and conforming to the pace of the guide.

The object of Battalion manœuvres is either to effect a change in the primary formation of the battalion, or a change in the position of that formation.

CHANGES OF FORMATION.

Changes of formation are designed,

1st. To facilitate the movements and changes of position of the line. Hence changes of position generally involve preliminary changes of formation, or—

2ndly. Changes of formation are designed to substitute one order of battle for another, when circumstances require the change.

Columns and echellons are, in the British Service, formations made use of to effect changes of position.

Squares and the open formations of skirmishers are instances of changes in the order of battle.

Columns.

Columns may be formed either to the front or to a flank, by methods to which, on account of their simplicity, it is not necessary to advert.

The strength of the divisions of a column and the distance between them is regulated by the purpose for which it has been formed.

In Route-Marching and Defiling the front of the division is determined by the breadth of the road or defile; and, as a general rule, full distance ought to be preserved between the divisions, since, if the intervals were less, the ranks could not be opened and the files loosened without the danger of the divisions becoming mixed,

while, if the intervals were greater, the compactness of the column would be destroyed, and its capacity for manœuvring impaired.

In Columns of Manœuvre, that is, in those columns which are formed with an immediate view to the re-formation of the line, it is generally advantageous that the front of divisions should consist of as many files as can move in line without disorder. The divisions of a column should, therefore, generally consist of companies, or where the front of the company is small, columns of grand divisions may frequently be adopted with advantage.

The proper distance between the divisions depends on the immediate object in view. If a formation is to be made to a flank, the divisions ought to be formed at full distance; but if to the front or rear, the divisions should be closed until the intervals are only sufficient to preserve the separation between them, and line should be formed by deployment.

The interval of one pace, which is left between the divisions of a British column when closed, will not admit of the free passage of the officers, and is, perhaps, scarcely sufficient to prevent confusion. In the French Service, six paces is the prescribed interval between the divisions of a column, *serrée en masse*, which, on the other hand, appears too great for a minimum.

In forming to a flank, single columns are the most convenient; but in deployments and other front formations, double columns on the centre ought always, when practicable, to be adopted.

Echellons.

The method used in the British Service for determining the angle of the wheel of oblique echellons by reckoning 8 paces on the circumference of the arc wheeled by the eighth file for the quarter circle, four for $\frac{1}{8}$, two for $\frac{1}{16}$, and so on, depends on the circumstance of $\frac{21}{30}$, the ratio between the space occupied by the front of a file and the length of a pace, being not very different from the ratio of the radius to the quadrant: since, therefore, circumferences are to one another as their radii, it is evident that whatever may be the strength of the division, the number of paces taken by the outer man in wheeling will always be nearly equal to the number of its files.

In the practical application of this rule much inaccuracy is produced by the serjeants not taking the number of paces ordered in the true direction of the arc: the inaccuracy proceeding from this cause is probably quite as great as if the angle of the wheel were determined by the eye, as is the case in the French Service.

Squares.

The British method of forming squares from column of companies is attended with the inconvenience of separating companies into fractions. By forming square from column of grand divisions, this inconvenience is avoided in the French Service, and the parts of a company are not separated by this manœuvre.

CHANGES OF POSITION.

There are four methods by which a Battalion may be fixed in a given alignment.

First. By establishing the flanks of the divisions in the alignment, and wheeling them backwards or forwards into line; or, if moving to a flank, by the divisions forming on their leading files.

This method is of extensive application in effecting changes of front, both of the battalion and of larger bodies.

The divisions may either be formed in column perpendicular to the alignment, or in echellon, oblique to it. It is not even necessary that they should be parallel to one another. The accuracy of the formation entirely depends on the position of the pivot flanks of the divisions, and is not at all affected by the direction of their fronts.

Second. By directing the march of a column along the rear of an alignment, and prolonging the line by the successive wheel of the divisions to the reverse flank.

In prolonging a line by this method, each division should wheel up in double time, otherwise the succeeding division will overtake it before the wheel is completed, and the march of the column will be impeded.

Third. By wheeling a close or quarter distance column, so that its front may be parallel to the alignment, and deploying on any named division.

Respecting this method, Guibert, who wrote soon after its invention, thus expresses himself:—

"This is the most clever (*savante*) of evolutions, the most susceptible of combination, and yet, both in its conception and execution, the most simple of all. We owe it to the King of Prussia; from his armies it has spread to those of all other European nations."

For the changes of position of extensive lines it is seldom that any other method but that of columns and deployments will be found suitable. (*Vide* 'Field Exercises,' Part IV. Sec. 7.)

Fourth. By forming on any named division of a direct echellon, or by establishing a division in the alignment and forming upon it by wheeling the others into oblique echellon, so regulating the angle of the wheel that the lines joining their inward flanks and the points where they are to enter the alignment shall be perpendicular to their fronts.

A direct echellon is the disposition which is generally given to an army when about to engage, and considerable advantages have frequently been obtained by the skilful use and management of this disposition.—(*Vide* 'Field Exercises,' Part IV. sect. 6.)

In good ground, oblique echellons may be advantageously used for changing the position of a line of small extent; but when the ground is rugged or the distance which the divisions have to traverse is great, it is difficult to preserve the true direction of the march of the divisions.

Oblique echellons are, therefore, ill adapted for the manœuvres of extensive lines.

Annexed is a synopsis of the principal manœuvres contained in Part III. of the 'Field Exercises of the Army.'

The various changes of formation, direction, and position of which the line is susceptible, have been classified, and the different methods pointed out which have been established by regulation for effecting each of these changes.

In Foreign Services similar methods are made use of for effecting like objects.

SYNOPSIS OF THE MOVEMENTS OF A BATTALION.

Vide 'Field Exercises,' Part III.

I. CHANGES OF FORMATION.

2. Columns.
   - 1st. To the front, by the flank march of divisions.—Sec. 30.
   - 2nd. To a flank, by the wheel of divisions.
   - 3rd. Double, on the centre subdivisions.

3. Echellons.
   - 1st. Direct, by the successive march of divisions.—Sec. 44.
   - 2nd. Oblique, by the wheel of divisions.—Sec. 37.

4. Squares.
   - 1st. From line, on the two centre subdivisions.—Sec. 21.
   - 2nd. From column, on any named division.—Sec. 29.*

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* Sect. 22. The Oblong two-deep Square against Infantry only, for the protection of baggage, &c., has been omitted, as apparently of a character subordinate to that of General Manœuvre.—*Ed.*

A. When the change is directly to the front or rear, the alignments being parallel.

II. CHANGES IN THE POSITION OF THE LINE, THE DIRECTION OF THE ALIGNMENT REMAINING UNCHANGED.

1st. By advancing or retiring in line.—Sec. 14.

Plate I. fig. 1. 2nd. By advancing or retiring in direct echellon, and re-forming on any named division.—Sec. 44.

Fig. 2. 3rd. By the flank march of divisions; the divisions afterwards fronting and wheeling into line, or forming on their leading files.—Sec. 16.

Fig. 3. 4th. Advancing in open column from a flank, and re-forming line by echellon on the front division.—Secs. 18, 43.

Fig. 4. 5th. Advancing in double column from the centre, and re-forming as above.—Sec. 18.

6th. By retiring from either flank, or from both flanks, in rear of the centre, and re-forming line as above.—Sec. 19.

B. When the alignments are parallel, but the one outflanks the other. Fig. 5.

1st. By throwing the divisions into echellon, advancing, and wheeling back into line.—Sec. 37.

Fig. 6. 2nd. By forming close or quarter-distance column on any named division, conducting the column to the place required, and deploying.—Secs. 30 and 36.

C. In prolongation to a flank.

1st. By breaking into column to either flank, advancing, and again wheeling into line.

Figs. 7 and 8. 2nd. By divisions successively passing from either flank along the rear, and again wheeling up in succession.—Sec. 20.

III. CHANGES OF DIRECTION WHERE THERE IS A POINT COMMON TO THE OLD AND NEW ALIGNMENTS.

A. To a flank. Fig. 9. 1st. By the formation of open columns, and wheeling into line.—Sec. 24.

Fig. 10. 2nd. Wheeling a division into the new direction, throwing the others into echellon, and forming upon it.—Secs. 40, 41, 42.

B. To the rear. By the counter-march on the two centre divisions.—Sec. 23.

IV. CHANGES OF THE POSITION AND DIRECTION OF THE LINE.

A. To a flank. Fig. 11. 1st. Breaking into open column, and re-forming line either to the front or oblique to the front by echellon.—Sec. 43.

Fig. 12. 2nd. Breaking into open column, advancing, and entering the new alignment by the flank march of companies.—Sec. 25.

3rd. Marching in close or quarter-distance column to the point of formation, wheeling the column into the new direction, and deploying.—Secs. 33–36.

Fig. 13. 4th. Advancing or retiring in double column, and forming to a flank.—Sec. 18.

Plate II. fig. 1. 5th. Advancing in direct echellon, changing the front of the echellon, and forming on any named division.—Sec. 44.

Fig. 2. 6th. Advancing in direct echellon, determining the direction of an oblique alignment by means of a point placed in advance of the leading flank of the echellon, establishing the rear divisions in that alignment, and wheeling back into line.—Sec. 44.

B. To the rear. Fig. 3. Breaking into open column, and forming to the reverse flank by the successive wheel of divisions.—Sec. 26.

C. Do. from column.

1st. By the divisions counter-marching and deploying.

2nd. By counter-marching the column, by the wheel of subdivisions round the centre, and deploying.—Sec. 34.

MANŒUVRES OF THE LINE.

A division of infantry deployed in order of battle may be reduced to a line of contiguous battalion columns.

This line may be formed into a mass of columns either to the front or to a flank.

Line may be re-formed to the front by deployment, or to a flank by the wheel of the battalion columns.

Changes in the position and direction of the line of columns may be effected by echellon or other methods.

The columns of which the division of infantry is composed, corresponding exactly to the companies of a battalion, and each manœuvre being precisely similar in principle to the corresponding battalion manœuvre.

When, therefore, an extensive line is to change its position, whatever may be the nature of that change, the general principle by which it is effected is the same.

That principle is—

To form columns of battalions.

To manœuvre with these columns so as to establish either their fronts or their flanks on the new alignment.

To re-form line by deployment, if to the front; or by opening out and wheeling, if to a flank.—*Vide* Part. IV. Sec. 7.

It is not necessary to examine separately such movements of the line as are effected by methods similar to those which have been already noticed in connection with the movements of the battalion.

There are, however, some of the dispositions and movements of great bodies which are not analogous to those of a single battalion, and which, therefore, require separate consideration.

DOUBLE LINES.

In manœuvring a strong division, it is usual to dispose the troops in double lines parallel, and, generally speaking, conformable, to one another.

In effecting changes of front, the following simple method for preserving the parallelism of the lines is given among the 'Evolutions de Ligne,' in the French 'Ordonnance sur l'Exercice et les Manœuvres de l'Infanterie."

Plate II. fig. 4.

The Officer commanding having determined the direction of the new alignment by means of a distant object (O), an Officer places himself at *f*, 50 paces from B; he then marches out perpendicularly to the alignment, till he reaches *e*, in the alignment B, O, where he is halted by a Staff Officer (S). B and *e* are the base points of the first line.

To trace parallel to it the new alignment of the second line (C, D), a Staff Officer having determined its distance by assuming the point P, a coverer is placed at *m*, 50 yards from P: this coverer paces (*m*, *n*) perpendicular to A, S, and equal to *f*, *e*.

P, *n*, will be the base points for the new formation of the second line, and the alignment can be prolonged by means of Adjutants and coverers to *x* and *y*.

CHANGES IN THE DIRECTION OF THE MARCH OF A MASS OF COLUMNS.

In changing the direction of a mass of columns, if, like the divisions of a battalion, each column wheels in succession at a fixed point, and then continues its march in the new direction, it is evident that the rear columns will be checked, and that dis-

tances will be lost. No method is laid down in Part IV. of the 'Field Exercises' for avoiding these consequences.

Annexed are two modes of performing the manœuvre prescribed in the French 'Ordonnance.'

First method.

The column is halted at some distance from the point where the change is to take place. The leading battalion then marches to the point, wheels into the new direction, and continues its march until it has traversed a space equal to the total depth of the column; it then halts. The other battalions follow in succession, each being put in motion when the preceding one has gained 40 paces to its front. When all the battalions have wheeled, the column resumes its march.

Vide Note 8.

Second method. Plate II. fig. 5.

The column having arrived at A, and it being intended that it should pass the point D, and prolong its march in the direction D, S,—in place of the march of the column being directed on the point D, the guide of the leading division, on arriving at the points A, B, C, and D, under the guidance of the Officer conducting the column, successively turns into the directions A B, B C, C D, D S, and marches on the objects P, Q, R, and S. The guides of the rear divisions follow exactly the traces of the leading guide, each turning into the new direction at the points A, B, C, and D.

When the guides turn into a new direction, the other men bring their shoulders forward, and gradually conform to it.

If care be taken so to select the points P, Q, R, and S, that the changes of direction be not very abrupt, the direction of the column is altered without creating confusion or interrupting its march.

CONCLUSION.

In order to form a just idea of the grand manœuvres of armies, it must be remembered that the movements of large masses of men are of a mixed character, and that the changes of position of an army are effected partly by ordinary marches, and partly by systematically combined movements of the fractions of corps.

The leader of a strong division, having received from the Commander-in-Chief general instructions respecting the ground he is to occupy, and the manner in which his troops are intended to act, conducts his division along the roads which debouche on the point indicated. On arriving in its vicinity, he collects his corps in columns, and directs such manœuvres to be executed as are either suitable for developing his force according to the prescribed disposition, or as are rendered necessary by the circumstances in which he finds himself placed. The first part of this process—that of conducting the troops to the point of assembly—requires, *comparatively speaking*, little art or tactical skill. The difficulty consists in the second part of the process, that of arraying a mass of men according to a predetermined plan, and of making such alterations in this disposition as circumstances may require. This can only be effected when, through the medium of organization, systematic methods are made use of by a person of sufficient intelligence and decision to adapt these methods to existing circumstances. This is equivalent to saying, in order that a mass of men may be effectively employed in warfare, the mass must be composed of soldiers, and its leader must be a TACTICIAN.

The selection of points to be occupied or assailed, the determination of the force to be directed on each, and the indication of the lines by which great changes of position are to be effected, constitute that branch of the Art of War which is called the Science of Grand Manœuvres.

The arrangement of these grand manœuvres is the office of the Commander-in-

Chief, and depends on considerations quite unconnected with the training of troops, or with any particular system of evolutions.

But, on the other hand, the rapid and regular execution of these arrangements, which alone can render them successful, entirely depends on the existence of a well-organized system of evolutions, on the skilful application of that system by the Officers in command of corps and battalions, and, above all, on each individual soldier being carefully trained to obey implicitly, to move steadily, to form rapidly, and under no circumstances of danger or difficulty ever for an instant to forget that instinct of combination and immediate and implicit obedience which is the essence of military strength.

It is only when a body of men is thus constituted that its numbers become formidable, and its energies available for great achievements. Numbers without order, instead of contributing to strength, only serve to render more disastrous the consequences of weakness.

Valour without discipline, so far from being sufficient to secure success, has frequently no other effect than to precipitate the moment of ruin.

NOTES.

1. The word 'Tactics' is in this Paper used to denote the science of military formations and movements.

2. Without appealing to the experience of those who are familiar with what occurs in actual warfare, every one who has witnessed even a *Field Day* knows that firing has a tendency to loosen the files. If, therefore, the natural order were found to be the best, and adopted as the rule of formation, would it not follow that the divisions of a battalion ought to deploy with intervals between them, so as to admit of the files being loosened without confusion?

There is no tactical point of greater importance, or which is worthy of more careful investigation, than the determination of the most advantageous mode of occupying ground; that is to say, the extent of front being given, the determination of the number of men and the manner of disposing them, whereby the most effective fire can be secured for its defence.

The importance of this point being accurately determined will be manifest, if it be considered that both the development of the line of battle and the proportion of casualties have obviously a direct dependence on the density of the formation.

3. The means of keeping this force effective, or the determination of an establishment for the battalion which shall be adequate for supporting the casualties incident to military service, is a question which is perfectly distinct from the determination of its proper effective force. This question of the establishment which corresponds to a given effective force is both interesting and important; but it depends on considerations which do not belong to the subject of tactics, (as defined in Note 1;) it cannot, therefore, be discussed in this place.

4. If part of a line be marching on level ground and part on a slope, in order to preserve a correct alignment, the rates of march of these two sections must be unequal, since it is evident that the section on level ground is traversing the side, and the section on the slope the hypothenuse of a right-angled triangle.

5. One of the manœuvres practised in the French army is the wheel of the

battalion in line. The wheel and echellon march of battalions is one of the methods prescribed in the 'Ordonnance' for changing the front of extensive lines.

6. Supposing the battalion to consist of 800 men, if composed of eight divisions, the front of a division would occupy 35 paces, which, in order that the depth may not exceed the front of the column, requires that a division and its interval shall not occupy more than five paces. If organized in ten companies, the front of a division would occupy 28 paces, which, preserving this ratio between the front and depth of the column, would only allow three paces for a division and its interval.

7. The Roman legion has been often cited and studied as a model for the organization of large military bodies; it must not, however, be supposed that in the formation of the line of battle, each legion was always arrayed as a distinct corps, and that parts composing it were invariably kept together and disposed in the same order.

On the contrary, we find that the cohorts of different legions, like the battalions of different divisions, were sometimes detached, and arranged, not according to any system of tactical organization, but in the way which was most suitable to existing circumstances. E. G.—Cæsar, in his 'Commentaries on the Civil War,' informs us that, on one occasion, when manœuvring against Afranius, he drew up his army in three lines; that his first line consisted of 20 cohorts, four from each of his five legions; that his other two lines each consisted of 18 cohorts, viz., 3 auxiliary and 3 from each legion, or 15 legionary cohorts.

" Cæsaris (acies) triplex: sed primam aciem quaternæ cohortes ex quinque legionibus tenebant, has subsidiariæ ternæ, et rursus aliæ totidem, suæ cujusque legionis subsequebantur."—*Com. de Bel. Civ.* lib. I. lxxxiii.

8. The method of changing the direction of a mass of columns practised by the garrison of Dublin in 1844 was similar to the first of the two annexed French methods of performing this manœuvre.

THE MARCH OF INFANTRY CONSIDERED AS A BRANCH OF SPECIAL TACTICS.

" Tout le secret de la Tactique est dans les jambes." — *Les Rêveries du Maréchal Saxe.*

Not only when viewed in relation to the science of General Tactics, but also when considered as a branch of Special Tactics, the subject of marching presents itself under two different aspects; and in treating of the details connected with the marching of troops, as well as when treating generally of the movement of masses, it is necessary to keep in view the distinction which exists between marches of route and marches of manœuvre.

The objects of these two species of marches are essentially different; and in order to perceive distinctly, and to appreciate justly, the principles by which each species ought to be regulated, a definite idea must be formed of the nature of these objects.

ROUTE-MARCHING.

To traverse the greatest possible space in the least possible time, and with the least possible fatigue to the troops, may be defined to be the object of route-marching.

The variations of this maximum and of these two minima evidently depend on the strength of the soldier.

What is this strength able to accomplish? By what means may it be most effectually husbanded?

It is with reference to these questions that the fundamental principles of route-marching must be determined, and the regulations established by which it is to be governed.

Let us interrogate experience in order to ascertain what distance troops may be expected to march in a day.

History has recorded the length of the "*justum iter*," or regular day's march of the Roman legionaries. We know that 20 Roman or 18·4 English miles was the distance fixed by the greatest military nation of antiquity as a fair daily task for the soldier. The complete alteration in the mode of fighting which has taken place since the invention of gunpowder, and the consequent modifications which the art of war has undergone, render the practices of the ancients in many cases quite inapplicable to the circumstances of modern armies; but the proper length of the day's march depends on physical circumstances, which during the lapse of ages have undergone no alteration; and since no troops ever surpassed the Roman legionaries in the frequency, the length, and the arduousness of their marches, so we may fairly infer none are better qualified to determine the proper limits of the day's march than the military legislators of ancient Rome.

Let us then assume on the faith of these great authorities that about 18 English miles is the minimum* which at all times, and during long-continued marches, ought to form the daily task of the soldier; but that during peace, and under ordinary circumstances, troops should not be harassed by journeys of a greater length than the distance fixed for the regular day's march.

It is a more difficult task to determine the maximum distance which good troops may be expected to march, when the exigencies of war require that their strength and energies should be taxed to the utmost.

Both ancient and modern history supply us with many examples of marches of extraordinary length: perhaps it may here suffice to quote one of these notable marches.

Napier informs us that the light brigade joined Wellington at Talavera the day after the battle, having, during the hottest season of the year, marched a distance of 62 English miles in 26 hours. This is an extreme instance, and shows what it is possible to accomplish when a single strenuous effort is required of good troops.

The state of the weather and condition of the roads must always exercise a great influence in determining both the advisable and the necessary limits of the day's march. These limits, therefore, cannot be otherwise than extremely variable and uncertain.

This uncertainty renders the combination of marches an element of military calculations, which is extremely liable to error, and which it is difficult to estimate correctly. Guibert justly remarks, "Many warlike operations fail from ignorance how to combine with precision the times, the distances, or the nature of the roads."

Let us now consider by what means the toils and fatigues of the march can be reduced, and the soldier's daily task performed in the easiest possible manner.

In this inquiry we can derive no benefit from the wisdom of the ancients. No account has been handed down to us of the minutiæ of their discipline, nor of the

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* The strength of the soldier is not the only measure: the delays by baggage, artillery, &c., must be taken into consideration, which will reduce the 18 probably to 15.

precepts of detail by which their marches were regulated. The best modes of training and preparing for pedestrian exercise are, however, well understood; many salutary regulations are at present in force to provide for the comfort and ease of the soldier on the march; and it is probable that others might be devised which would still further tend to promote these important objects.

The chief points to be attended to in the conduct of marches are—

1st. The equipment of the troops.

2nd. The order of march.

3rd. The rates of march and intervals of rest.

4th. Precautions to be observed at the end of the march.

A few observations on each of these points will conclude this review of the subject of route-marching.

1st. *Equipment of the Troops.*—This is not the place to enter into a general discussion respecting the costume and equipment of the soldier. To inquire whether the fashion of his uniform is well adapted for bodily exercise? Whether the weight of his kit is reduced to the least possible amount? and whether the burden he has to bear is arranged and suspended according to the most scientific principles?

These inquiries are highly important, and have a direct bearing on the soldier's capacity of enduring fatigue; but it will here be sufficient to notice that part of his equipment which has the most immediate and essential connection with the subject of marching,—viz. the clothing of his feet.

Too much care cannot be taken that the soldier's socks be thick and soft in their texture.*

That his shoes have strong broad soles and low heels; that they fit easily, and that previous to a march they be softened with grease.

Rubbing the feet with soap is also recommended as a method of preserving the feet. On the due observance of these and similar precautions the condition of the soldier's feet principally depends; and as the majority of men who fall out on the line of march are disabled, not by fatigue, but by sore feet, it is obvious that no part of the interior economy of a company should be more carefully superintended by its Officers than the state of the men's shoes and stockings.

2nd. *Order of March.*—On the line of march, when no enemy is at hand, it is the custom of all armies to free the soldier as much as possible from the restraints of the parade ground. To loosen the files; to open the ranks; to allow the men to carry their arms as they please; to abandon their measured pace; to converse with each other; and, in short, to trudge along as cheerfully as they will, and as easily as they may. Such is the extent of the licenses which the regulations of the Service grant the soldier at the word "March at ease:" perhaps the principle on which these licenses are granted under certain circumstances admits of being carried out a step further.

In time of peace, when to move from point to point (not to manœuvre) is the object of the march, and when between one halting-place and another no formation is contemplated, why should not the sections march at double or even treble distance?

In the march of a strong column, inconvenience might arise from thus doubling or trebling its length; but in the case of a regiment or a detachment, no inconvenience would be felt from so doing.

By increasing the distance between the sections, and by taking care that, when

* If this cannot be secured, better take off the stockings altogether.

formed at close order, their front should not exceed half the breadth of the road, crowding and jostling would be avoided, and the greatest possible freedom from dust and heat secured to each individual soldier.

It is scarcely necessary to remind any one who has marched with troops how a song with a chorus, or a lively air played by the band, invigorates the drooping spirits of tired soldiers.*

3rd. *Rates of March, &c.*—In order to march a given distance with the least possible fatigue, it is of great importance that the rates of march and intervals of halt should be properly regulated. If the rate of progression be very rapid, the strength will be exhausted by the violence of the exercise; and if very slow, will be worn out by its long continuance.

Between these extremes there must be a medium rate of march, which is the most favorable for husbanding the strength, and by using which a given distance will be accomplished with the least possible fatigue to the soldier.

In order to determine this medium rate, it would be highly desirable to ascertain by an extensive series of careful and varied observations on the march of troops, what degree of quickness of step is least fatiguing to the soldier, and most easily sustained by him throughout a day's march in heavy marching order.

It would be also useful and interesting to determine by accurate experiments the absolute rates of march, or ratios of distances to times, which correspond to different degrees of quickness of step.

These investigations would not only furnish useful data for regulating the conduct of marches, and for the calculation of military movements,† but would also serve as a basis from which principles and considerations might be deduced for selecting and combining that length and that quickness of pace which are most suitable for the attainment of precision and uniformity in manœuvring.

Table No. I. will be found, which presents a comparative view of the rates of march established by regulation in the armies of several different nations. Judging from the want of uniformity in this fundamental part of the soldier's training which the Table exhibits, it may be presumed that the discovery of some principle to fix the proper standards for the length and quickness of the military pace is still a desideratum in the Science of Tactics.

Of these two elements which enter into the composition of a rate of march, it is evident that one,—viz. the length of the pace—has a functional dependence on height, and will, therefore, when not artificially regulated, of course vary in different individuals.

The annexed Table shews the results of some experiments made by the writer of this Article with the view of determining his own rates of walking.

It indicates that the length of the pace is very considerably modified by its quickness, and that as the rate of motion is accelerated, the length of the pace is increased, though not in a uniform ratio. If, as seems probable, the *ratio* of this increase is in a great measure independent of height and other individual peculiarities, this relation between the length and quickness of the pace is worthy of being accurately investigated, and ought certainly to be considered, and, if possible, preserved in constructing artificial rates of march for military purposes.

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* Attended to more in Foreign Services than in ours.

† Some principle might be established of *never* loading the soldiers with more than one day's biscuit and 30 rounds of ammunition, except on very urgent occasions, and loading bât-horses with the complement of both, instead of harassing the men.—*Editors.*

TABLE I.

Lengths of Pace and Rates of March corresponding to Steps of different Degrees of Quickness (the height without boots being 5′ 9″).

No. of steps per minute.	Variations of like Pace.				Rates of March.		
	Length of pace (inches).	Difference from mean length=32·71 (inches).	Difference from preceding value (inches).	Ratio of successive differences to mean length of pace D : 32·71″ : : 1 : *x*.	Yards per minute.	Miles per hour.	One mile in — minutes.
100	31·06	−1·65			86·28	2·941	20′ 23″
108	31·01	„ 1·70	− ·05		93·05	3·172	18′ 55″
115	32·19	„ ·52	+1·17	27·95	102·83	3·619	17′ 7″
120	33·73	+1·2	1·54	21·29	112·47	3·834	15′ 39″
125	33·8	„ 1·9	·07	467·3	117·37	4·001	14′ 59″
130	35·08	„ 2·37	1·28	25·55	126·68	4·318	13′ 53″
Average	32·71						

Note.—The values given in the Table are averages deduced from repeated observations of the times of traversing known distances. During each set of observations the distance traversed varied from 14 to 17 miles.

If accurate Tables similar to the above were formed from sufficiently numerous observations on the march of troops in heavy marching order, then by a simple reference to the number of paces per minute, (an element which is easily ascertained and controlled,) the duration of marches might be estimated, and their rate regulated with very great precision.

A rate of march being determined suitable to the circumstances of the case, and the nature of the object to be attained, its conformity would be easily preserved by making an officer or non-commissioned officer march at the head of the column, and regulate the quickness of the pace by occasional reference to a watch.

The duration of halts and the proper intervals between them must have considerable influence in modifying the fatigues of a march. In the Standing Orders of the Light Division, most of which, we are informed by the Editors, originated in observations made in the field by the late Major-General R. Craufurd, it is directed, "that the first halt of a column shall take place half an hour after it marches off, and that afterwards, at the end of every hour, it shall halt for at least five minutes."

4th. *Precautions after the March.*—With a view to the preservation of the men's feet, it is the custom in some regiments, immediately after the conclusion of the day's march, for the Company Officers to go round the billets and see the men paraded without shoes and stockings, in order to ascertain that their feet have been properly washed and cleaned. A Medical Officer also visits the billets and dresses the feet of such of the men as are badly blistered.

As it is not always possible for a Surgeon to perform this duty, perhaps it might be useful to promulgate a few simple directions, pointing out the best way of treating blisters, and to commit the enforcement of these directions to the Company Officers.

II. MARCHES OF MANŒUVRE.

It is necessary that separate bodies manœuvring together should move at the same rate, in order that the proper intervals may be preserved between divisions, and that tactical combinations may be executed with precision.

It is also necessary that the soldiers of a division should move at a uniform rate, in order to prevent the files separating from one another, and thereby deranging the correct dressing of the line, on which the direction of the march of the division, and consequently the accuracy of its movements, entirely depends.

From these considerations, with reference to the purpose of this Paper, it follows, that in manuœvring, *Uniformity of Motion is the principal object to be attained.*

This renders the march of troops, when executing military evolutions, perfectly different in its character and principles from those marches which have no other object than to move them from one place to another.

In manœuvring, the rate of march is no longer a measure of the strength of the soldier, varying according to the quality of the troops and the circumstances which affect their ability to sustain the fatigues of the march, but is a uniform rate strictly defined by regulation, and at all times and under all circumstances among the soldiers of the same army remaining perfectly fixed and invariable.

In order that the motion of a body of men should be perfectly uniform, it is evident that the cadence and length of the pace of each invididual must be precisely the same.

Accordingly, in all highly disciplined armies the careful training of the recruit to such a measured pace, regulated by the constant use of the plummet and pace-stick, is the basis of the whole system of tactical instruction.

In these artificial systems of marching, the motion ought to be entirely from the hips, and the length of pace ought never to be so great as to cause the slightest derangement of the steadiness of the body and squareness of the shoulders.

In all existing codes of military instruction, two principal rates of march, termed by the French "*pas cadencés,*" are taught the recruit.

The slower or fundamental rate is used in teaching the principles of marching in parade movements, and in those manœuvres, such as the march of lines, where the greatest precision is required, and where individual irregularities have the greatest effect in disturbing the movement of masses. The other rate, in some Services termed the "deploying step," is that which is habitually used when the manœuvre is executed by a combination of the movements of divisions of a small extent of front.

Regularity, not rapidity, is the principal object to be attained in ordinary manœuvres, and the regulation pace ought never to be so quick as to cause the slightest hurry, crowding, or confusion in the ranks.

In addition to these two principal rates of march, in some armies troops are drilled to a running pace, applicable to certain special exigencies of warfare.

This is a very useful part of the instruction of the soldier, for, although in making a rush to seize a contested point, it is probable that no discipline will equalize the step of the bold and the timid, yet in many circumstances — such, for example, as sudden formations against cavalry — both great regularity and great expedition are absolutely essential to the safety of infantry.

Guibert, in his admirable Essay, makes the following observations concerning this rate of movement: —

"The treble or running step cannot be restricted to any fixed degree of quickness,

because its quickness ought to vary in proportion to the importance of forestalling the enemy, the distances to be traversed, and the object to be attained after traversing these distances. I consider it as the step to be used in all cases where a great acceleration of speed is necessary.

"Therefore, in order to forestall the enemy on an essential point, to turn his flank, to deploy, and be prepared to charge before he is formed, the rate of this step should be carried to its utmost limits; but in such cases the soldiers must not be expected to maintain equality of step, uniformity of time, or the symmetrical order of the files: it ought to suffice if they advance in silence, if the files are kept separate, if they do not get before their officers; and if at the word '*halt front*' they close in, halt, and regain their places."

There is another observation of Guibert's which is worthy of notice, as illustrative of the nature of the considerations which determine the character of the march suitable to military evolutions.

He says, in great manœuvres, when large bodies of troops change their position, many of the divisions having to traverse broken ground and to march considerable distances, that to subject the men to the constraint of a measured pace is, under such circumstances, neither necessary, nor is it practicable. That such movements should, during the greater part of their extent, be conducted on the principles of ordinary route-marches, and that it is only when the march of each battalion is near its termination, when it is about to deploy, or to enter an alignment, that its compact order should be restored, and the regulation pace resumed.

Different nations have adopted different standards for the regulation both of the length and quickness of the military pace.

The variations of these standards (as will be seen by reference to the annexed Table) are by no means inconsiderable.

Comparing the lengths and rates given in it with those of Table I., and assuming that the allowances which must be made for the effect on the length of the pace caused by the weight of a knapsack, and by the difference between five feet nine inches, (the height given in the Table,) and whatever may be the average height of the army, would not materially affect the results there shewn; taking it for granted also that these results present a tolerably near approximation to the natural relation which subsists between the length and quickness of the pace corresponding to the height and degrees of march given in the Table; then it will be observed that the proportions of the British quick-step are more consistent with this natural relation than the military steps of any of those nations with which it has been compared.

And since the constraint of stepping short is quite as harassing as the exertion of stepping out, it cannot be doubted that in those systems, such as the American, and especially the Spanish, where a very short has been combined with a very quick step, that this violation of a physical law must have an injurious effect in increasing the difficulty of training the recruit.

It may also be noticed that the British and Prussian paces are those which approach most nearly to the length of the military pace of the ancient Romans.

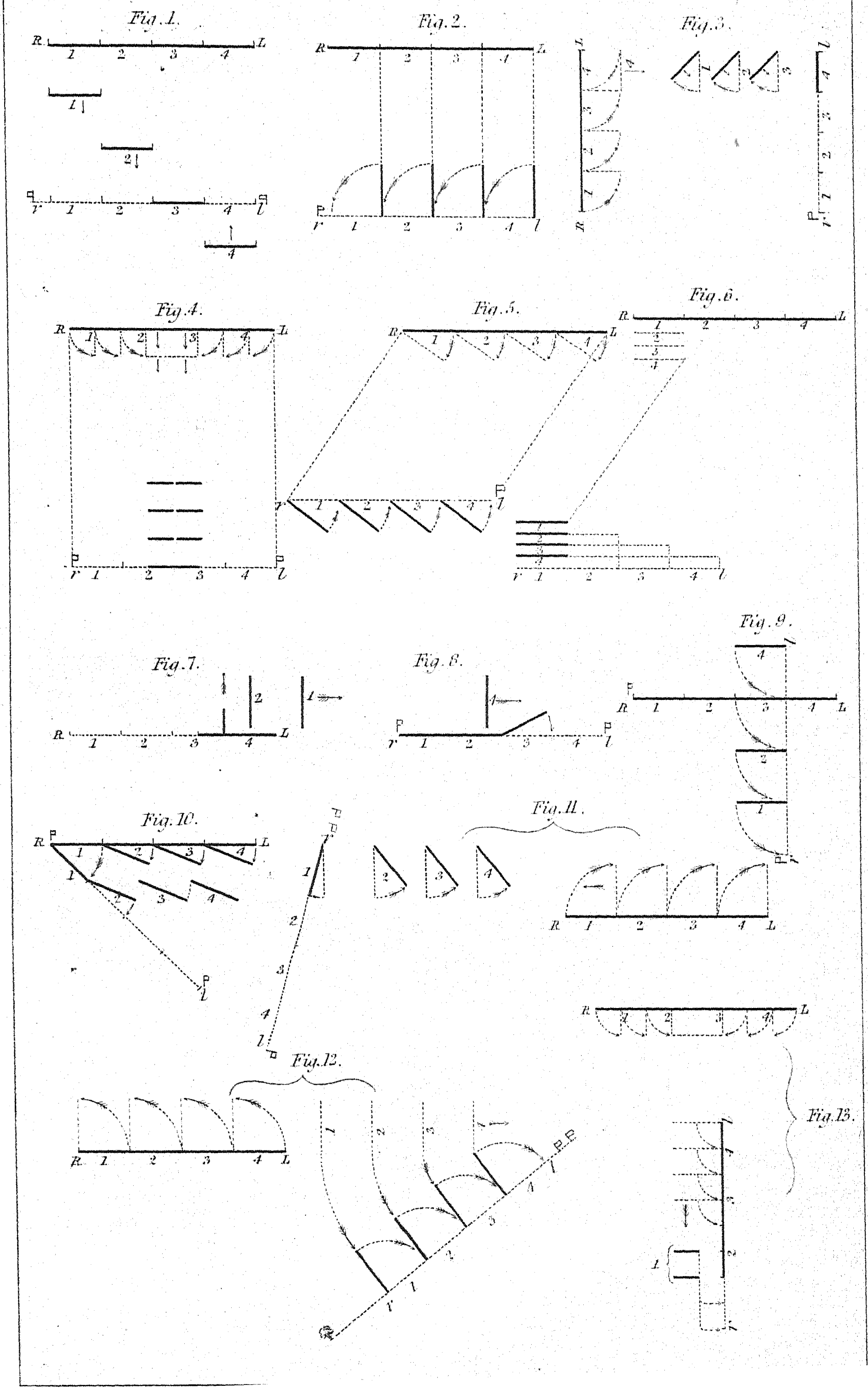
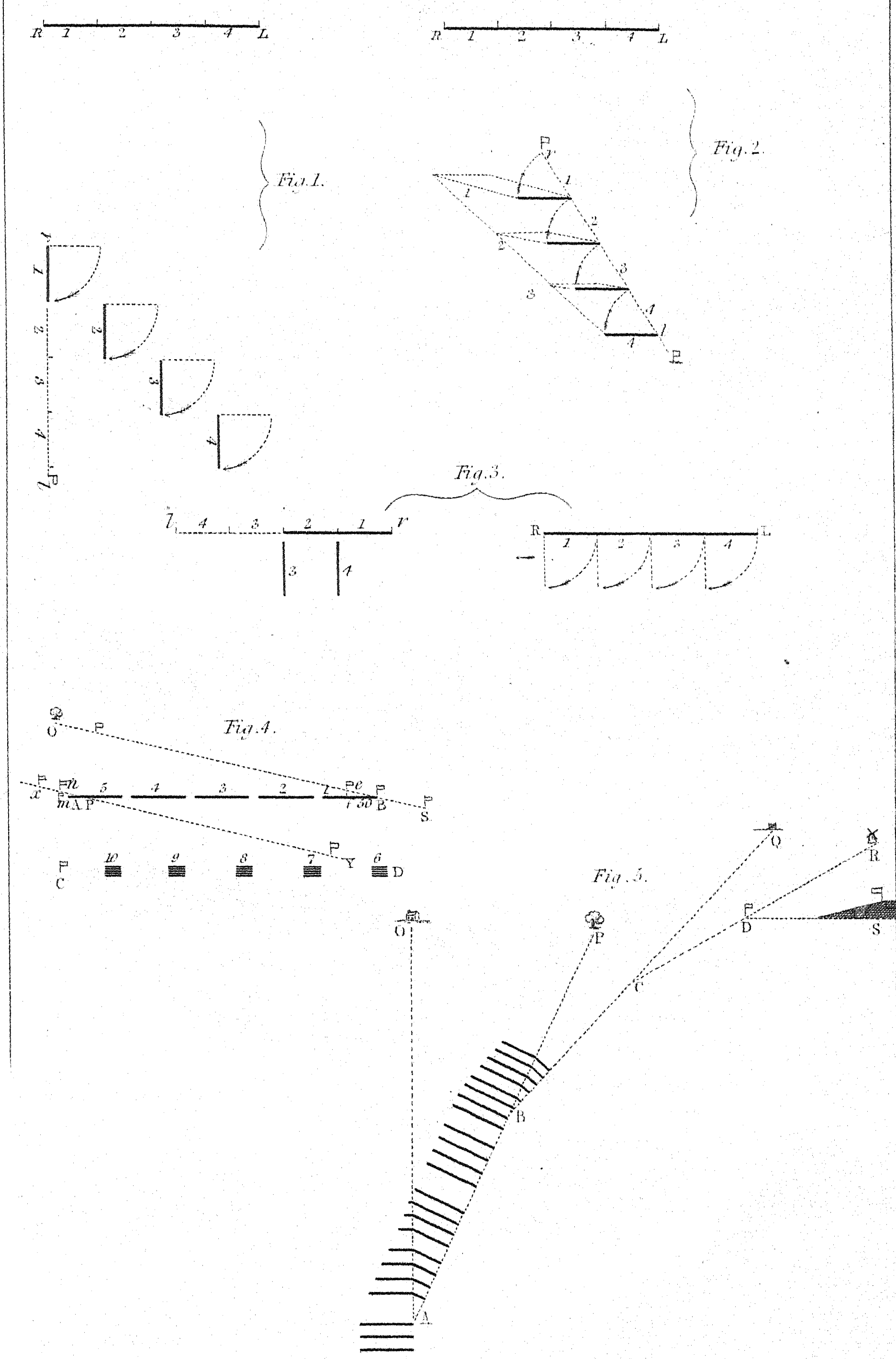


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.
Fig. 12.
Fig. 13.



C. Robertson del.

TABLE II.

Lengths of Pace and Rates of March established by Regulation in several different Armies.

Name of Nation.	Name of pace.	Length of Pace.		Rates of March.	
		Foreign Measures.	British inches.	No. of paces per minute.	Yards per minute.
British . . .	Slow step Quick step Double step		30 do. 36	75 108 150	62·5 90 150
French . . .	Pas ordinaire Pas accéleré Pas redoublé	65 centimetres Do. Not given.	25·59 do. not given	76 100 140 to 150	54·02 71·11
Prussian . .	Ordinairer schritt Geschwind-schritt For the charge	2 fuss. 4 zoll. Rhinland measure Do. Not given.	28·83 do.	75 108 120	60·06 86·49
Austrian . .					
Russian . .					
Spanish . .	Paso regular Paso redoblado	2 pies Do.	22·25 do.	76 120	46·97 74·17
United States.	Common step Quick step		28 do.	90 120	70 93·33
Ancient Roman	Passus Militaris ($\frac{1}{2}$)		29·18		
Average . .	Slow step Quick step		27·31 do.	78·4 111·2	59·47 84·36

Note.—The length of the Roman pace has been calculated on supposition of there being 75 Roman miles of 100 double paces to a degree. The Prussian rates of march have been taken from Scharnhorst; the others from the Regulations of the different Services.

In making the reductions the following values have been adopted:

Metre . . . = 39·37 inches.
Rhinland foot . = 12·356 „
Burgos foot . . = 11·128 „

EVOLUTIONS OF ARTILLERY.*

ARTILLERY ACTING WITH OTHER TROOPS.

1. When artillery is attached to other troops, and that its movements are to be regulated by them, the Commander should manœuvre so as not to interrupt them.

* From 'Instructions and Regulations for Field Battery Exercise.'

2. He (as well as every other officer) should be well acquainted with the evolutions of troops, for he will then know the ground which they will go over in performing any manœuvre, and will never impede them; moreover, he will be enabled to arrive more quickly at the position he is to occupy.

3. Though in matters of review the artillery should generally conform as nearly as possible to the movements of the troops, yet a latitude should be given to the Commander to depart from this rule whenever he may see it necessary, and when he thinks he may attain his object by acting differently.

4. In all alignments of troops, the artillery should never be brought up nearer than sixty yards from the intended alignment, till the points of it are finally established, when the Commander will move it up to its position, twenty yards in rear of the line, where it will remain: by this means, should the whole move to a flank, the artillery will be clear of the line of pivots.

In Line.

5. When the artillery is ordered into line, or, at review, when the General is about to appear, Nos. 1 of each subdivision move out, and place themselves one pace and a half in rear of the front rank of the troops, and facing to their subdivisions. The artillery move forward, Nos. 1 halting their subdivisions when the leaders come up to their own persons.

6. Should the artillery be ordered for action, and be required to fire, it will move forward previous to its unlimbering.

7. When the guns are in action, the axletrees are to be in a line with the front rank; and when they are ordered to limber up to the front, they must be run back so as to leave the alignment clear.

8. The artillery should always cover the troops when advancing, retiring, or deploying into line.

9. In line, the artillery will generally be placed on the flanks of the troops to which it is attached; and if there be no other troops on its outward flank, there will be sufficient room for it to move freely. When, however, it is to be drawn up between two bodies of troops, it must manœuvre as much as possible on its own ground. The Table at the end shows the number of yards for a battery of six guns in line and in column. With less, the artillery will be confined.

10. The distance which artillery can move in advance of a line must always depend upon the support it can receive from the troops or covering party, and from the nature of the ground. The Commander must always be guided by the position and manœuvres of the enemy. Should there be any favorable positions, or risings or swells in the ground, advantage should be taken to place the limbers under cover.

11. If the line is to advance after deployment, the artillery must gain ground to the front, while taking ground to the flank to uncover the troops as they deploy.

12. When the line advances and approaches the battery which covers the advance, the Commander will, in proper time, push forward the half-batteries alternately, either limbered up or with the prolonge.

13. When artillery is in action on the flank of a line, it should, in general, be placed more or less in echellon, in order to bear obliquely on the enemy in front.

14. When the line retires by alternate companies, wings, or battalions, the artillery must remain with that part of it which is nearest the enemy; retiring with the prolonge, and halt when it arrives with the halted part of the line.

15. When the line changes front to a flank on its centre, the artillery, with the flank thrown back, should cover it, retiring with the prolonge; the artillery on the other flank covers its advance.

16. When the line is thrown backward or forward on one of its flanks, some of the guns nearest the halted flank may be run into line by hand.

Column.

17. When the troops are in column, the artillery should be on the reverse flank.

18. If the artillery be at the head of the column, and from obstacle or a narrow road, it becomes necessary to diminish the front, it should be done before the head of it arrives at the spot; so that no delay may be caused in the rear.

19. Whenever the ground becomes too narrow for both troops and artillery to march on the same front, the artillery should endeavour to get to the head of the column, or it will probably have to wait till all the troops have passed.

20. When a line of troops wheels backwards into column, the artillery, in breaking into column, must close to the reverse flank, so as not to interrupt the line of pivots. When the column is put in motion, the reverse guns open out to the proper intervals.

21. When there are troops both in front and rear of a column of artillery, and that, in order to facilitate the movement, the carriages go so far to a flank as to leave the space between the two columns of troops entirely clear, two markers should be posted just within the line of pivots, to mark the situation of the flanks of the artillery, and to preserve a proper distance for it between the columns of troops.

22. In column, with troops both in front and rear, the artillery should never open out, if it can be avoided, to more than the distance it stands upon in line.

23. The infantry generally wheels backwards from line into column. If the artillery wheels forward, instead of breaking into column, there will be a false distance between the rear of one and the front of the other. The Commander of the artillery must correct this by slackening his pace.

24. It is always essential to procure sufficient room for artillery to move in, and when between two columns of troops, never to crowd the carriages so much as to diminish this space.

25. When the troops are in line of contiguous battalion columns, the artillery should be in line on the flanks of the line of columns, at the usual distance of 20 yards from the front of the leading companies of battalions.

26. When a mass of columns, or a line of contiguous columns, advances previous to deployment, the artillery must be pushed forward to the position which it is to occupy when the line is formed.

27. When the troops retire in column, the artillery should retire on their flank, when the ground will permit; but if the column enters a road or défilé, the artillery which is to cover it must place itself in the rear, retiring with the largest possible front.

Squares.

28. For the position of artillery when the infantry form squares, see Article 4.*

29. It may be as well at reviews not to fire when riflemen or other troops are in front of the artillery; although, in reality, the guns can with safety fire round shot, if necessary, over their heads, or through any large intervals which may be between the advanced bodies.

30. When the roads are good, or even tolerable, the artillery is always obliged to wait for the infantry, which is attended with much additional fatigue to the horses, from having their harness so much longer upon them. When, therefore, there is no danger, the artillery should be allowed to regulate its own rate of marching.

31. One of the most important objects that can be attended to is the march, when troops are to assemble at a fixed time and place. The Commander of artillery may, with judgment and experience, save much unnecessary fatigue to both men and horses, by taking into consideration the state of the weather and roads, and regulating his movements accordingly.

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* This alludes to another part of the work from which the extract was made.

EVOLUTIONS OF CAVALRY.—*Vide* 'MANŒUVRE.'

FASCINES.*

The two descriptions of fascines used in sieges are those for revetting and tracing. Great care and some practice is necessary to make long fascines well and expeditiously. They should be, when finished, straight, cylindrical, and pliant; bound round with good thick unbroken gads, or withes, at equal distances of not more nine inches asunder, the knots well tied, and all in one line; no variation in the girth, exceeding one inch, to be allowed.

Much depends on, and much time will be saved by, attention, in the first instance, to the fixing of the trestles firmly and accurately. The two stakes are usually tied together with rope or twigs; but they will be much steadier if fastened by a wooden pin. The rope-lashing may then be added to advantage, particularly if it fills up somewhat of the angle, thus giving a better shape to the fascine. It is of consequence to have the stakes for the trestles of squared wood, as being more easily arranged with accuracy; and great care must be taken that they cross at right angles, and that the intersections cover well in line. The ground should be level, and the trestles not more than 2 feet 6 inches apart. The stakes may be ripped out of old 3-inch platform plank, in battens 4 inches broad; and if required for any length of time, the whole set of trestles may be kept steady by strips of wood running along, and nailed to them, outside.

No dry wood should be used in the fascine, if green can be obtained in sufficient quantity. The longest and straightest stuff outside, the more irregular and the smaller within. There should be plenty of small brushwood to give compactness by filling up interstices. The largest branches may be 1½ or 2 inches thick at the butt.

Fascines for revetting must be made at once of the proper length, and not sawn off at the ends, except when for embrasures, where the inside ends must be even. Not only should revetting fascines be left rough at the ends, but the ends of the branches should be cut to a slant, so that when forced into each other, a better joint may be more readily made. All leaves must be stripped, but the twigs may remain.

The gads must be of the most pliant wood that can be procured; if possible, from 1 to 2 inches thick at butt. They are twisted and wrought until pliable. The 'eye' should be made as soon as a sufficient length for binding is secured, and not left as a matter of course to the very smallest part, which the men are apt to do, to save themselves trouble. If, as with oak, the wood does not twist readily, it can be softened by being passed through the fire. To preserve the suppleness of the gads, they may be kept in water.

Four men are enough for a revetting fascine: two prepare the stuff, two arrange it on the trestles. They should make one of eighteen feet in three hours.† They

* From the Notes of Major-General Sir J. F. Burgoyne, written at Ciudad Rodrigo in 1812.

† In the preparations for the siege of Bayonne, 1814, the Portuguese parties of the Line, employed on fascines and gabions (on which kind of work they are regular, diligent, and particularly clever), made at the rate of twelve 18-foot fascines every six men per day, at one set of trestles, besides their proportion of pickets (84); the stuff, which was very good, being 'delivered;' and the bands of spun yarn. They were paid 8*d.* for each 18-foot fascine with its seven pickets. It made little difference, as to time, whether they used spun yarn, or willow gads. The above party made eight 18-foot fascines in six hours easily.

Very great allowance, however, must be made at first starting with English soldiers; and reckoning

will require four bill-hooks, a fascine choaker, a mallet, and guage sticks for proper dimensions of their work.

When sufficient stuff has been laid on the trestles, the choaker is passed round at about ten inches from the ends, and pulled by two men until an inch or so less in girth than it is intended to be. It is then tied close to the choaker, or at nine inches from the ends. The binding then proceeds from the ends to the centre. Binds, nine inches apart.

The usual mode of tying the knot is by passing the thick end of the gad through an eye in the small end, and then twisting the thick one round itself in a kind of oblique spiral; but this will frequently loosen, particularly if left exposed to the sun; besides which, the eye is very apt to break by its sharp bend, and the strain upon it. The knot will be better tied by passing the thick end (previously well twisted) *round* the eye, and then doubling it under the side of the gad, by means of a little pointed stick of hard wood, by which the greatest stress is laid on the thick part, instead of on the weakest.

When spun yarn can be procured, it will save time, and does away with the most difficult part of the operation. The band should then consist of four yarns, passed twice round the fascine, besides the knot.

It is of little consequence how fascines are made which are not for revetting, so that they are tolerably compact and firmly made. Any thing of nearly the proper length, tied in two places, will do for tracing fascines. These are generally considered as fatigue-work; the parties only take out bill-hooks, and tie the fascines as tight as they can, without choakers; and, instead of trestles, lay the stuff between two pair of upright stakes, a foot asunder, fixed into the ground just to support the stuff until tied. Large parties may be sent out, and tasked at two or three 4-foot fascines per man. Cavalry ought to take their share of this duty; and, if they can be spared with their horses, might be sent for gads, which are frequently more difficult to be found. They should be brought in bundles, of fifty each, 4 feet 6 inches long, and as thick as they can be had, to the size prescribed.

Tracing fascines are of the greatest service; and, indeed, in parallels, almost of absolute necessity, as they make it easy to preserve a banquette, which it is nearly impossible to do without them.

Fascine pickets are also usually considered fatigue-work. They may be brought in without points, but something longer than the actual length required, and the straighter the better. They are only required for revetting, and at the rate of seven per 18-foot fascine.

FIELD SKETCHING:—chiefly in reference to military purposes, though also bearing on what are more technically called 'Field Sketches' in General Surveying.

This subject will be considered in four Sections.

I. Notices on the Apprehension of Ground.

II.* Preliminary Arrangements and Instruments, &c., necessary.

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on future improvement, so arrange prices that they may, with encouragement for the present, eventually earn from 15*d.* to 18*d.* per day, by diligent exertion.—J. F. B.

* Section II. ought to have been 'on the Expression of Ground,' in reference to the forms characterizing the rock or soil of which the hills are composed. It is *hoped* that sufficient materials for this will be collected for 'Topography.'

III. Sketching at leisure, and under no restriction from the neighbourhood of the enemy.

IV. Sketching against time, and in the neighbourhood of the enemy.

SECTION I.

NOTICES ON THE APPREHENSION OF GROUND.

The agencies to which so much of the present nature, extent, and arrangement of geological formations are due, are still busied in perpetual, though, generally, very gradual changes on the surface of the earth in its Topographical Character; hence the forms of ground that usually occur may be reduced to the following classification:

Those last produced on various materials by the action of	A. Air,—as in sand-hills, *e.g.* in the Deserts and south coast of Africa. B. Water,—as in districts (other than the above) where no traces of volcanic action are visible. C. Fire,—as in volcanic districts. D. Of B and C conjointly,—as in districts of extinct and submarine volcanoes, *e.g.* the south-east of Sicily; or in now extinct volcanoes that have burst through B, as in the Eifel, Auvergne, &c.
Those composed of organic structures	E. Animal and Vegetable,—as in coral formations now in progress. F. Vegetable,—as in peat formations now in progress.

With exception of the immediate results of fracture from a central point, or along a line of disruption, nearly all the preceding forms are referable either to the actions of fluids and liquids on yielding matter, or to matter having been in a state of fusion; all bearing the stamp of 'fluid,' either as the physical character of the immediate cause of dispersion and subsequent re-arrangement, or as the original condition of once melted mineral substances. This relation to Fluid Action can rarely be lost sight of, whether in the instance of air on sand,* of water on earthy subjects, or of fire in the fusion of lava torrents.† And there is a characteristic resemblance observable in all three classes accordingly; but for most purposes it will be enough to consider B and D only, regarding the peculiarities of the remainder, however interesting, as rather matters of curiosity than of practical importance.

At the present day, it is unnecessary to shew that all formations, from the tertiary downwards, and much of the post-tertiary, have been under water; and that B and D became, on the whole, decided and fixed on their emergence therefrom: hence, to obtain the forms characterstic of B,‡ excellent studies may be found in natural models of a large extent of country on muddy shores, from which the water has just receded. Here we find mimic mountain ranges, then their subordinate hill districts, and these last passing insensibly into the gentle undulations of the last hillocks as they are finally lost to sight under bogs, marshes, or like level deposits, or in the sea
Plate III. itself,—the valley and the ravine, the river and the streamlet, the lake and the pool, and nearly all the topographical features of aqueous formations acted on by water,

* The forms of well-settled and frozen snow, subject to gusts of wind sweeping down the ravines or valleys, on the bottom of which it lies, have at times a close resemblance to hill forms; very different from the fantastic shapes of newly-fallen snow, which agree well with those of sand-drifts.

† One of Hecla's streams is mentioned by Lyell as upwards of 90 miles in length.

‡ The instructive and beautiful little models of Mr. Dawson (well known to Engineer Officers of the writer's standing) relate principally to forms of this class and D. It is much to be wished that our venerable friend would arouse himself to perfecting a series of these unique performances, and undertake the article 'Topography,' in which he has few equals but no superiors.

both as to original formation, and to subsequent abrasion. The defects lie in these representations being somewhat exaggerated where the mud is very soft and the bank rather steep; and also, in the absence of such main features as are given by the bold intrusions of igneous rocks; though, when these are modified, as in D, by aqueous agency, they are represented with considerable fidelity.

With regard to Class D, remarkably defined and instructive studies from nature will be found in the Irish mountains, which are nearly all disposed in isolated groups, separated from each other by flat lands, a large proportion of which is bog.

On whatever scale the subjects of study may be,—

The master-lines of ground are,

1st. The main or summit ridges of the mountain or hill . . . . 2nd. The water-courses	Referring chiefly to classes B and D.
3rd. The coast or horizontal contour lines	Referring to all.

The subordinate lines are those more or less oblique contour lines, defining the minor features, and generally called feature lines.

ORDERS I. AND II.

THE RIDGE AND THE WATER-COURSE.

Plate I. In aqueous formations there is always a close conformity of parallelism between these two lines, as in Plate I. fig. 4, between NO and LL′ or MM′. In those of igneous character there may be only a very general one between the crest of the upper regions and the lines at the base; though, as we descend, this parallelism increases till the lower grounds are reached, which being usually composed of B or D, again admit of the above-mentioned "close conformity."

In reference to these two orders of lines, the first thing to be done in rock and clay formations (excluding both diluvial* and alluvial flats from the latter) is to study well the general character of the district in relation to the nearest mountains or extensive hill range, so that the representations may have the force of truth, and be well characterized by a significant reference TO THE WHOLE, *of which it is but a part*, as far as the extent of ground permits. This is indispensable in plans of considerable tracts of mountainous or hilly country; and where several persons are to be employed in its execution, there must be one guiding head, to give this speaking character, and one qualified to insure its observation in all the performances of the assistants. In small portions of ground, such as a camp, an ordinary position, or battle-field, &c., these considerations are not quite so important; but still the spirit, clearness, and simplicity of the work, will always be more or less dependent on this principle being borne in mind.

Plate III.

In formations of loose sand and gravel (like those extending from the east of Holland, for upwards of 1000 miles, across the north of Germany, into the heart of Red Russia, skirting the northern slopes of the Harz and Bohemian mountains, without a hill exceeding 400 feet in height,) this relationship between the mountain range and its lower members soon disappears; and the character of such ground is best obtained by studying carefully delineated charts of shallow seas, or like formations, such as those of the German Ocean, especially towards the coasts of Holland and the Straits of Dover; the hills being in this case without any very obvious relations, either as successive and subordinate heights, or as to lateral connection.

Water-courses. The forms produced by water-courses descending from each side of the ridge

* This expression is still retained for post-tertiary level grounds, senior to what is obviously alluvial.

(called also the 'Water-shed' line, from thus parting the waters,) are but few in number, being dependent on the relative positions of the streams as they find their way down to their 'primary'—the principal river—on its course to the nearest lake or sea.

Whatever may be the size of the stream, whether it be the largest river or the smallest streamlet, or the miniature channels traced on the mud-bank model, there exists, from the nature of the case, like results from like causes under like circumstances: thus the water-shed line under consideration may be the crest of the Appenine chain, or it may be the scarcely perceptible swelling of ground determining the direction of small rills to the different parts of a farm.

Plate I. fig. 1. Streams descending slopes will (normally speaking) either be perpendicular, as *a b g h* to the water-shed (W X), or they will be oblique to it, as *c d e f*. Any two of these, taken together, will give the elementary forms of water-courses; thus *a* and *b* give A, as the type of the Douro and Tagus, or better, of the Tagus and Guadalquiver, or of parallel rivers in their general course. B, the result of *c* and *d*, corresponds to the confluences in which rivers more or less originate, as those of the Punjaub, at the head of the Indus; in the same way that C (or *e* and *f*) represents the delta-shaped divergence common at the mouths of large rivers, as the Nile, Indus, Ganges, &c.

Plate I. In fig. 2, relating to the valleys of streams on a far smaller scale, as these streams descend, the valleys deepen—hence the side slopes, *a b*, *a b;* and these, truncated by the valley (Y Z), to which they are tributary, present the front slopes *b b*, *b b*. These direct courses, however, seldom continue long, as may be observed at the bottom of the sea, where the currents are constantly being deflected by various causes; and Fig. 3. these (or the like) forms may be variously combined, as in fig. 3, where the first diagram is composed of A and B; the second of A and C; the third (a very common one) of D alone, or of B and C; the fourth of C and B; and so on. A further extension and combination of these water forms is shewn in fig. 4, the entire shape of which, as given by the two rivers L N, M N, is itself a compound of A and B, as in fig. 3, just as may be further exemplified by the Tigris and Euphrates; or as the union of A and C give the approach of the Don and Wolga, near Sarepta, before they finally separate for the seas of Azof and the Caspian respectively.

Fig. 4.

Thus, continuing this sort of action, we find, that, generally speaking, the construction of hill-ground as far as water-courses are concerned, is produced by the continual division and subdivision of main valleys by secondary valleys; of secondaries by those of a third order, and so on, till the process is terminated to the eye by the hills disappearing under some level, as the Rhenish hills do under the flat grounds of Holland, near Bonn, or the Welsh hills between Cardiff and Newport, in the red Plate III. marl flats; or else by their reaching the sea or a lake: though to a great extent, the same forms are found under water as above it, with this main difference, that they are still submitted to the action of the same power, to which all topographical formations of class B have owed their existence.

Pl. I. figs. 5, 6. In illustration of the above, figs. 5 and 6 are general diagrams of the ramifications of valleys at different points of their course; fig. 5, those of confluences, as, for instance, those of the head waters of the Elbe, in the Bohemian basin, or of the Amazon; fig. 6, the middle and lower part of the valley, and is by no means a much caricatured representation of certain slate districts,* which have been little or not at all affected by igneous disturbances, such as at certain points of the Great Fish River

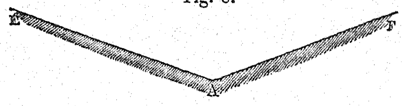
* Slate rocks have no exclusive claims to this: there is no reason why any well-stratified rock of equal consistence and equally horizontal beds, should not give the same results.

Valley, near De Bruin's Post, and still more so half-way between it and Graham's Town, or in the tributary ravine of the Ecca, in South Africa. This formality of shape is particularly conspicuous when the courses of the different streams either coincide with the dip and strike of the strata, or else directly cut through them at right angles. Certain portions of the Rhine (in the same rock) are equally rectangular, and the Rhone is, probably, still more so. Fig. 7 is the Delta terminating figs. 5 and 6, but only on the alluvial deposits at the mouth, beginning from the point where the valley ends.

Fig. 7.

Valleys, however, are not simply composed of two slopes, A E, A F, (as shewn in section, fig. 8,) intersecting at the river A, but in general of several successive planes sloping down from the water-sheds (E E′, fig. 9), such as E D, D C, C B, B A, either meeting on both sides in A, or separated by a flat valley bottom, A A′.

Fig. 8.



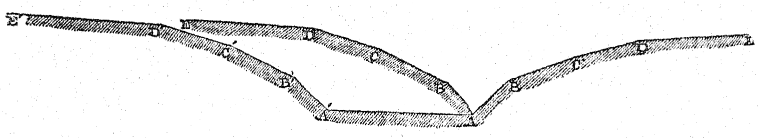
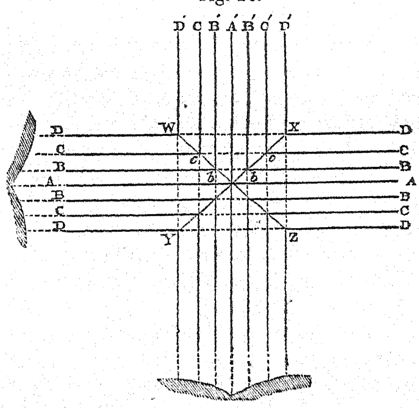


Fig. 9.

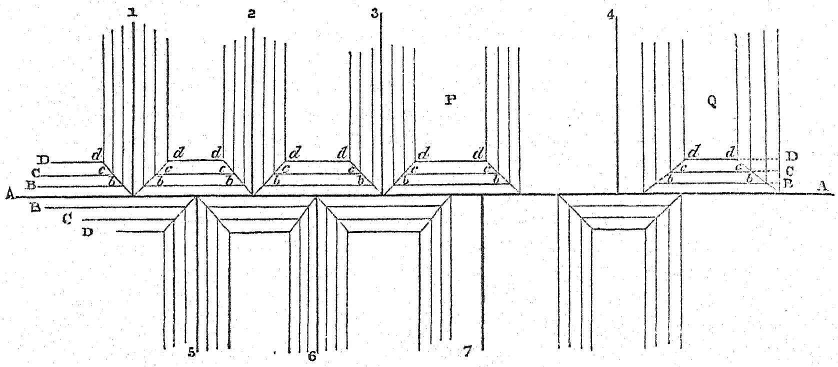
If two such valleys intersect one another, as in fig. 10, there will be a groin-shaped space (W X Y Z) formed; and it is of the greatest importance in sketching ground that the general form of the main valley be traced out by the significant correspondence pointed out by the dotted lines, between the truncated portions (D W—X D, C *c*—*c* C, B *b*—*b* B, &c.), and as if the general trench-shaped primary valley had never been invaded by the cross one.

Fig. 10.



Thus, in fig. 11, in representing the main valley A A, with its cross ravines, 1, 2, 3, &c., the original lines (D D) must still be indicated (or dotted out, as it were) by the fragments *d d*—*d d*—*d d*, &c.; C C, by *c c*—*c c*—*c c*, &c.

Fig. 11.



In Plate V. this principle is applied to a river (A) between the two water-sheds (W X, Y Z): the whole valley between these lines should be sketched with the feeling that the stripes or zones (across the mouths of ravines, Nos. 1, 2, 3) *e e*, *e′e′*, *e″e″* — *d d*, *d′d′*, *d″d″* — *c c*, *c′c′*, *c″c″*, &c., are still in existence. The same applies to the ravines themselves in reference to their own branches, as in ravine No. 4.

Attention to this is indispensable as a principal means of *representing ground as a whole*, in the manner adverted to in the earlier part of this Paper.

It should be remarked that where a river runs along a broad valley-flat, as on A A′, (fig. 9,) that it constantly changes its direction, as if repulsed, and rebounding from one side to the other; and at all sudden turns is to be found under the concave sides. On these last the banks will be steepest, even to being perpendicular cliffs, as is particularly observable in rocks with tolerably horizontal strata, (*e.g.*) the Wye between Chepstow and Tintern (Plate IX.), or the Dove, in Dovedale, both in mountain limestone; or the Great Fish River, with its bluff 'kranzes,' in what often amounts to flint-slate. In Plate V. this alternation of steepness has been neglected for the sake of simplicity, and the section E A E′ (fig. 9) has been followed, rather than E′A′, A E. This changing from side to side may likewise be observed on a good scale in mud-harbours and estuaries, such as Portsmouth, and the Hamoaze at Devonport; but more especially in their branches and creeks, in which, at low tide, this alternation of sides gives a good clue how to find the channel at high tides, even when guiding a party of boats in an expedition where one is a perfect stranger to the locality.

Water-sheds.

Referring to the last paragraph but one, and still in pursuance of the idea of representing ground as a whole, as far as it may be done without forcing and exaggerating what at times is scarcely perceptible, (as, for instance, in considerable tracts of the chalk districts, if taken at all in detail,) something must be said of the first order of master lines—the water-shed, or summit ridge — as equally important with the water-course, though not always so readily appreciable, very seldom appearing in the finished sketch, and therefore spoken of last, though almost the first to be indicated in pencil.

Plate II.

Although, for the sake of illustration, the ridge lines are given in the different accompanying diagrams, yet they are in dotted lines only, as they are never expressed in drawings, unless they should accidentally coincide with some otherwise minor feature line, as, for instance, at *b b*, Plate II., by a sharp ridge of rocks happening to run along the water-shed. Notice of them is, nevertheless, indispensable in original sketches, as fundamental memoranda, though they need then only be given, as above-mentioned, in pencil.

In Class B, water-sheds, as shewn by dotted lines in Plate I. fig. 6, may be considered as always so co-ordinate with the water-courses, that they may be almost invariably deduced from them,* and appended to the main ridges (W X, Y Z), as the streams are to the main river (A A).

Plate I. fig. 6. In Classes A and C, the subjects are too wild for any such formal connection. In the former, no particular representation is necessary, as the sand-hills vary in form and position with every wind, and it is therefore correct to express them conventionally, instead of specifically. In the latter class (C) the ridges are either those of forms of explosion, or else of lava torrents bursting out arbitrarily from any point in the sides of the volcanic cones; and far oftener so than from the main crater. In Classes E and F, as level surfaces, there is no appearance of this line, except, perhaps, where F, lying on, and thus forming part of, the high grounds, may happen to cross it. In Class D, as composed of B and C, there will be a combination of the principles of both; and, as before intimated, those of C (or their cognate effects, as forms of disruption amongst stratified masses,) will generally be prevalent in the upper, and those of B in the lower ground.

ORDER III.

THE COAST, OR HORIZONTAL CONTOUR LINE.

So far as the forms of ground have tolerably distinct outlines, as given either by a somewhat obvious ridge, or by the water lines, or by the boundaries of the various faces produced by the above-mentioned continual intersection of valleys, they may be given, as approximates to mathematical forms, in little more than clear outline, as far as the "Field Sketch" is concerned; but the section of the ground may be too low, and its shape no longer defined by facets (as if in a measure polyhedral), but by curved surfaces, both in plan and section.

'late IV. It is then that horizontal "contour lines" are called in to assist in the representation. They are such as would be given by successive risings of a flood to different levels: these will, in the first instance, start from the coast, though they soon lose all exact parallelism thereto, when the supposed waters, as they rise, find their way into valleys, and rise up the faces of the hills. It is evident that if ground be surveyed in this manner, and the heights of the different levels given, the plan of these contours presents the equivalent of a complete model of the ground. — *Vide* 'Contouring.'

It is very desirable that the student should practise this operation to a considerable extent, as he will obtain thereby a knowledge of the true forms of ground which cannot be had in any other way; though the nearest approach to this will be given by the mud-bank model. When *on* a hill, the eye takes in so little at a time, that if not thus disciplined, a beginner is sure to give too great a roundness and circular formality to his forms. A like remark applies to sections, which are sure to be made too steep by the tyro, who, apt to estimate steepness by the fatigues of ascent, is generally much surprised at the low relief of ground with apparently considerable elevation and abruptness, on making his first section of the same. It is on this

* Exceptions to this rule are found in tabular deposits of gravel, which have in general no very perceptible water-shed, such as those already noted in the north of Germany, Bagshot Heath, Woolwich Common, and Blackheath at the foot of Shooter's Hill,—this last belonging to the *clay* portion of the London Clay Formation. The water-courses, however, are very distinct in these gravel plateaus, the sides of which are usually abrupt, and cut into numerous small hills,—such as those in Greenwich Park; the Repository and the 'Roughs' at Woolwich; the pleasure-grounds in the neighbourhood of Hamburg, on the banks of the Elbe,—or the banks of the Oder, at the Brüche, near Freienwalde.

account very desirable to study your ground at a distance, (for general correction as to relative importance of the different features,) as soon as the local details have been collected on the spot. The best times for this are a little after sunrise or a little before sunset.

These horizontal outlines (of horizontal sections) are strictly applicable to sketching, with regard to the shading touches being also horizontal, or nearly so. This style is very generally used at present, in preference to the vertical mode, which, however, is by some considered to have greater force in the expression of *very* steep ground, and is, perhaps, more easily understood in hasty sketches, where but little detail is admissible; though both styles become objectionable where they are made, unnecessarily, to supersede the simple outline for the main features, where this (the outline) would be clearer, and more rapidly executed than any quantity of shading.

As memoranda for subsequent study and completion, the best plan is to combine both, as shewn in Plate II.; but when every thing must be made to speak as simply and quickly as possible, this would be a misplaced and not generally comprehensible refinement,—and the rough but significant hieroglyphics of Plate XI. are far preferable.

The relation of this Order III. to I. and II. is best seen by supposing, either on the mud-bank model, or on the actual face of the earth, what changes of topographical nomenclature are dependent on the supposed elevation or depression of the waters above or below the present level,—when the inland sea, the gulf, the bay, the lake, become the grand valley, or the mountain basin, convertibly.

Let the waters retire sufficiently, and the bed of the Mediterranean becomes the grand valley of a new river, issuing from between the pillars of Hercules, as the conjoint result of the Nile, the Danube, Don, Dneister, and Po, besides numerous other new rivers of respectable magnitude. Let the waters rise, and Bohemia reverts to its probably former condition as a lake, of about the size of Lake Superior; the upper Alps become bold groups of islands; and the whole space now occupied by the Amazon and its branches resumes the character of an immense gulf, as large, perhaps, as both the Bay of Mexico and the Carib Sea together.

Thus the name and character of Order I., either as the Line of Shallowest Soundings, or as the Water-shed;—or of Order II., as the Channel of the Deep, or as the Water-course,—are terms depending entirely for their application on the level of the Third Order; and in the orthographic expression of ground, no one may decide on their relative importance. The First and Second are indefinite and unmeaning without the Third; and the Third is mechanical and spiritless without the First and Second.

The 'Contour' is particularly applicable to Classes E and F, especially the former; as peat formations are not exclusively, though very generally, confined to level, and especially lower grounds: abundance of water is indispensable to the plants of which they are composed; and as water is to be found on the side of a hill, as well as at the top or bottom, the peat-plant (generally Sphagnum Palustre in Britain and Ireland) will be found in any of these positions. In the Irish insular groups of hills, before mentioned, a very large proportion of the flat grounds thus representing water is filled with it, as the *sine quâ non* of the existence of these vegetable formations. Plate VIII.

The masses of animal and vegetable* skeletons composing the coral formations are

* Corals are not exclusively produced by animals; they are extensively secreted by marine plants; and amongst the animals whose skeletons are thus accumulated, the Zoophyte (as is generally assumed) is by no means the sole constructor: Serpula, and probably many others, contribute largely to these formations.

necessarily (especially when incomplete) exclusively arranged in contours,—whether round nuclei of Classes A, B, C, or D, they conform to coast lines, or aggregate round the heads of sub-marine hills, in belts which cannot in any case rise above spring flood tides, and very generally—depending on the nature of the animal or plant—above those of the spring ebb. Whether these belts fill in subsequently or not, the external contour remains unaltered.

SUBORDINATE LINES,

such as *a, a, a, a,* in Plate II., occupy the same rank in the delineation of ground that the markings of the muscles, folds of flesh, &c., would in the representation of the body, after the main outlines, descriptive of the head, eyes, limbs, &c., have been given:—as thus subordinate, they are termed Minor Feature Lines. Where they refer to curved surfaces, they will be made somewhat to swell towards the centre, as would be done in the line that would express a cheek, a muscle, &c.: they will be more rigid as the forms become more angular.

SECTION II.

PRELIMINARY ARRANGEMENTS FOR FIELD SKETCHING.

The whole district to be represented should be apportioned off to the assistants by the person who is responsible for the combination of the different parts.

The assistants should work together in the first instance at their common boundaries, to such extent as will insure agreement on the lines separating their respective portions.

To effect this agreement and general consistency, the skeleton diagram of the whole should be formed from the best and available authorities, giving the positions of the main points. If there be no trustworthy maps to supply these, they must be obtained trigonometrically, if the space exceed about 10 miles square, and the scale be greater than 2 inches to the mile.* It is in vain to expect accuracy, or even tolerable general coincidence amongst the parts, when every man works quite independently and without triangulation.

Each assistant should receive his sheet with those points *pricked off* from the general diagram that concern himself, and which will therefore include many of those surrounding, but not on, his own ground: of these he should make as much use as he can, so that as much as possible of the work may be relatively right, notwithstanding the moderate amount of absolute error which ought to be expected on this duty. The meridian should likewise be given from the general diagram.

INSTRUMENTS, &c.,

Necessary to be prepared for Field Sketching with advantage.

The sheet should be *well* supplied with fixed points, as above.

The meridians ruled as normal lines, either at fixed distances (see Plate VIII.), say 1 inch (or ½ mile) apart,—or else passing through the main points: both plans have their advantages.

The paper should be stretched so that the edges be secured from the wind; and there should be the means of covering it from the rain. Where, as in Section III., there is leisure and convenience, experience has shewn that a board, even of the size

* A carefully chained base, and the skilful use of the pocket sextant, will provide for this space: if the points are not much more than two miles apart, it will not be necessary to compute the distances trigonometrically, but to lay these down by the protractor, constructionally, as in Plate VII.

of a sheet of demy paper, (hinged in the middle, made of the thinnest and lightest wood that will bear the *framing* at the edges necessary to prevent warping, and supplied with a flapped Macintosh bag as a cover, fitted with a strap for slinging it over the shoulder,) amply repays the trivial inconvenience of carrying it, by the additional number of surrounding points that it can include. When, as in Section IV., this would be out of the question, the sketch-book, described in the note to Section IV., and tested by the long and arduous experience of Colonel Bainbrigge,* leaves nothing to be desired: with this last, portions only, such as single lines of road from point to point, and the ground immediately adjacent, are sketched at a time (see Plate XI.), and are combined on a general skeleton afterwards. The hinged board has the advantage of enabling one to complete every thing on the spot, (a skilful sketcher need rarely go over the same ground twice, where there is no impediment to his movements,) and thus becomes a convenient substitute for the somewhat antiquated plane-table.

Plate XI.

The only instruments generally necessary in field sketching are a Schmalcalder's compass and a drawing scale; but in basaltic districts, or any other in which iron, in a form capable of affecting the needle,† abounds, instruments for taking included angles instead of bearings must be substituted, such as Colonel Bainbrigge's field goniometer, or the pocket sextant,—the former being by far the most satisfactory invention on the reflecting principle as yet invented.‡

The most convenient drawing scale is the white metal, or even the common ivory protractor, $6'' \times 2''$; three edges occupied by degrees, § the fourth cut to 40 to 1 inch, as a very useful scale for general use, being applicable to any multiple or sub-multiple of the mile (or 80 chains), especially when two inches to the mile is adopted, which is very commonly the case for the general sketch, of which parts can be enlarged subsequently for positions, lines, &c., as may be required. If preferred, this fourth edge can be cut to the paces per mile of the draughtsman: when this is not done, it will save much time, and possibly error, to have a small table of paces (peculiar to each person) as far as 20 chains, engraved on the scale. (See Plate VIII.)

Plate VIII.

The best material for sketching on is the Bank-post paper: when well made it is remarkably tough, and though thin enough for tracing through, yet it stands a great deal of severe work: by working at once on this, the *original document* is always preserved, which is not the case when asses' skin is used, and which entails loss of time, and the chance of error incident to copying.

The requisite colours, &c., will be Indian ink, sepia, Prussian blue, gamboge, and lake, for topographical purposes: when dispositions of troops are to appear, add cobalt, chrome yellow, and carmine, as being better suited, from their brilliancy, to catch the eye at once. The remaining items will be a small memorandum book, brushes, pencils, the metallic pens ‖ now so much used, knife, and India-rubber.

* Deputy Quarter-Master-General in Ireland, and C. B., to whom we are indebted for the materials of Section IV. For the details of this instrument see 'Topography.'

† The carbonate of iron is not magnetic: hence the needle is used in surveying the iron mines of South Wales, where the ore contains the metal in that form.

‡ Reflecting instruments have the great disadvantage, when used for fixing one's position from given points, of requiring three of them, and the construction given in 'Formulæ, Trigonometrical;' whereas the compass requires only two points, and needs no construction beyond that of laying down the bearings to obtain their intersection.

§ Troughton and Simms, Fleet Street, London, make a good strong scale for sketching ground, with lines perpendicular to the lower edge that go quite across the scale, and which are very convenient when the normal lines, as shewn in Plate VIII., are used.

‖ Those of zinc, as but little liable to rust, are perhaps the best.

Many an inconvenient day's work, or vexatious walk back, will be saved by calling over the *muster-roll* of these things before starting.

SECTIONS III. AND IV.

INTRODUCTORY REMARKS.

In both of these Sections, the degree of detail in which the ground is to be shewn must depend on the purpose in hand; and in Section IV. on the time and opportunity afforded, to which in Section III. no limit is placed.

In Section III., without indulging in topographical niceties, a full account may be given of every feature of sufficient importance to be represented. In Section IV. nothing should be noticed that can be omitted; and the work in its rough way should speak as clearly and simply, as (with greater leisure for consideration) Section III. should clearly and amply. Thus, in Section III., and in the case of a chalk district, in which, from the absorptive nature of the soil, the streams are usually few and small, it might be proper to notice a rivulet which then and there might be topographically important, or which, for Engineer purposes, might be wanted to form an inundation; but it would be absurd to notice it in Section IV. when insufficient to stop even Infantry,—unless the ground were that of a camp, where the stream might be of consequence as a provision of water.

Plates XI. and XII.

In Section III. more or less of pen-work may be allowed, especially in representing the usual topographical hieroglyphics, as given in Plate VI., though the brush, with a little assistance, will work with far greater rapidity and equal force, with reference to hills, woods, marshes, &c.; and in general, for this Section, it may be said that the brush is in every way preferable to the pen or pencil when circumstances admit of its use, which is by no means always the case. Every use, however, should be made of the conventional signs of colour, especially in shewing water in blue, forests by flat shades of green, &c. No attempt should be made at expressing relief by light and shade in the field, though in skilful hands it may be advantageously used at home.

Plate VI.

What is wanted in Section IV. is something very simple and effective, that can be executed with sufficient accuracy and with the greatest dispatch, and which may be immediately comprehensible by the General Officer for whom the sketch is made, under any circumstances of embarrassment and perplexity; and facility in doing this is *only* to be obtained by being familiarized with ground, as the result of previous study, practice, and attention to instructions, such perhaps as those given in Sections I. II. and III.

SECTION III.

The sketcher is presumed to be equipped as specified in Section II., and to understand the use of his instruments, and other drawing apparatus: it would lead to much unsuitable detail to attempt memoranda on these subjects.

Having carefully studied the ground in reference to the purpose in hand, and to the views given in Section I., proceed to detail and embody the ideas thus generally formed in the manner shewn in the following example,* in which it is assumed that no fixed points have been supplied (as pricked off from any general diagram), and have to be determined on the spot.

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* The meridians have been omitted in Plates VII. IX. X. for the sake of clearness, but their use is shewn in Plate VIII.

Example 1, *Plate VII.*

Let A B C be the base, as obtained by pacing,—D, E, F, G, H, principal points fixed by intersections as they can be obtained, which, in a regular survey, would be obtained trigonometrically,—A 1, A 2, &c., &c., tangential bearings, which, by an early determination of the most important exterior points and lines, act as limits, preserving the work from distortion.

Suppose the object to be principally the peninsula;

Now as the heights running from D to F, do not offer a suitable base, from the interruption of the fort and the irregularity of the hills, the ground A B C should be selected for this purpose.

Commencing at A, take bearings to the Martello tower (D), the flagstaff (E), and the south-west salient (J) of the fort. While on the spot, to avoid a useless recurrence to the same (and in military sketching you should never, if possible, *work twice* on the same ground), take the tangents A 1, A 2, A 3, A 4, which give limits in *one direction* to such parts of the contiguous coast, &c., as can be seen; and before leaving the station, sketch in as much of the ground as you can fairly judge, within a moderate distance all round; then pace on to B, noting such points as *a* (in the prolongation of the battery on the isthmus), or *b*, where you cross the road, &c., &c.; and this sort of observation should be CONSTANTLY made, as a general rule, inasmuch as you are then certain that the *relative* positions of the different objects are nearly right, although, in some instances, the *absolute* ones may be occasionally erroneous: it binds the work, as it were, together.

At B, *fix* D, J, and E, by intersecting the bearings taken at A; take other principal bearings to the point C, the tower F; also the tangent B 1, which not only gives a *limit* to the rocks at *d*, but one to the coast at *e*. Proceed as before to C, remarking that at *f* the towers F and G are in a line with yourself.*

At C, *fix* the tower F, by intersecting the bearing from B; and the point *e* by C 1, cutting B 1.

Having thus secured all the ground along which the base runs, on the north side of the gulf, return to the point *b* (where the base between A and B had crossed the road), and pace to, and lay down the works on the neck, sketching the ground to the right and left as you proceed. Plate VIII.

Plate IX.

As D has been already fixed, you need not *pace* up to it after marking down the redoubt and long battery on the isthmus; but on arriving at the said point (*b*) take bearings to H, and the tower G; also the tangents† D 1, D 2, D 3. In order to lay down the south front of the fort, pace a line (D *g*) as near it as the marsh *h* will allow: the remainder of the work can be completed from station E.

E. After thus finishing the fort, *fix* the towers H and G by intersecting bearings (E H and E G), and then prove the accuracy of the situation of F by E F. As the situation of B is more certain than that of C (since any accumulation of error from inaccurate pacing must of course be less on a short distance, A B, than on a longer one, A B C), E is a *senior* point to F (which was observed from C); therefore whatever position is given to this last from E, it must necessarily take precedence of that from C, and correction is to be made accordingly. For a like reason, if on arrival at Plate VIII.

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* Work may often be checked and verified without a single measurement being taken, by thus availing oneself of such coincidences and alignments.

† No opportunity should be missed of securing the general directions of the principal summits, crests, and slopes of hills by these tangential bearings, the continued intersection of which give much assistance in not only fixing the position of hills but also their true forms.

C, you found that the bearing C E passed east, or west of E, then shorten or lengthen B C, until the aforesaid bearing intersects exactly.

Next, place yourself outside the fort, as near as possible to E, judging the distance; and having laid it down, go towards F: this distance (E F) pace, not from being uncertain of the place of F, but in order to ascertain that of the neck lying between it and the fort.

Arrived at F, sketch the surrounding peninsula as nearly as may be judged, but not giving yourself much concern about it;—partly because the north side is already well defined by the tangents (B 1, E 1); and partly because you will see, that in going to the southern side of the main hill, and reaching the tower G, you will have abundant opportunities of laying down the south side of the peninsula (F) by such tangents as G 1, *k* 1, E 3.

Then return to D, and pace towards G, so as to obtain proper points (*i* and *k*) on the line D G: from these last (*i*, *k*) good intersections may be obtained (*i. e.* such as vary between 45° and 100° at the point where the bearings intersect) for fixing the point and houses (*m*); and from whence also tangents may be obtained to the shores of H *n* and *o*, by *i* 1, *i* 2, *i* 3,—*k* 1, *k* 2, *k* 3.

In like manner proceed for any other points; and a very limited share of practice will give ample experience as to sketching the intermediate ground. If, however, there should be any doubt as to the accuracy of any particular part, as at G 4, take a bearing in that direction from G, and pace on it to the point in question.

Memoranda.—The heights of the hills should, generally speaking, be given (usually in red) on the summits; and any conventional signs employed should be *invariably* explained in the margin;—such as those given in Section IV. to denote the different degrees of passability for the several descriptions of troops, &c.

In plans of camps and battle-fields, the top of the plan is always towards the enemy.

Houses of masonry in red; of wood in Indian ink.

Example 2.

This was sketched in reference to a project of defence once made for the ground opposite Quebec. As affording also a good field of action, it was accompanied by Plate IX., as an *Abstract of Facilities and Impediments*, independent of the hill-work: in the original, the spaces now shaded were flat washes of green, to shew the woods. From a sketch like Plate VIII. a much môre detailed plan can be made than would be necessary for any battle-field, where much of what is now given would be improper, especially as from the fragmentary character of this drawing there was no scope (or occasion as it happened) for further completion of the form of ground: as it now stands, it is only fit for a memorandum to enable the draughtsman to complete a finished and enlarged copy.

The topographical character of this ground is as given in Plate I. fig. 3 (A and C), and at P 4 Q, fig. 11, wherein a sort of hammer-headed peninsular hill (A) comes to the St. Lawrence with a flat valley bottom (B) between it and the next and like hill (C). These hills (A, C) are the last features of individual members of a series of offshoots from the water-shed separating the waters of the St. John from those of the St. Lawrence.

In sketching this ground, the road from Point Levi to Chaudière gave an excellent main base, not only for the ground between A and the river, but also for fixing the opposite or Quebec bank. The road D E F G, as a cross base, gave checks on many observations taken from the main base: it also afforded numerous points not to be

seen from this last, and determined to a great extent the true position of the back road leading from Beaumont and Beau Sejour to N'importe.

Example 3, *Plate X.*

Plate X.

In this, which is given as one of the most difficult cases, the road at the bottom of the deep and narrow valley (A, B) cannot be seen from the grounds above: the upper parts of this valley are so loaded with copse and young trees as to present not a single point for connecting them with the lower parts: hence the whole distance (A, B) had to be laid down by laboriously protracting the different lengths of the road as they successively presented themselves. This is a common occurrence in wild countries well covered with woods, and where the only roads lie where they cannot by any possibility be connected with the trigonometrical points. Protracting the line patiently as above is the only resource in this case. In Plate X. there is a quantity of detail in the direction and turnings of the road, which would be unnecessary for almost any military purpose,—though in this case it was unavoidable. The feature lines of all the ground, except the Gaer Hill, are remarkably sharp in many places, as is very common in the English mountain-limestone districts, in one of which the subject of this plan is situated.

In laying down this ground, the paced base lay between the Wyndcliff and a tree on Panter-Rede: from these, and the two intermediate points shewn on the diagram, every good object that could be seen was fixed,—such as Black-wood Cliff, Piercefield Cliff, and half-a-dozen remarkable trees,—all of which were visited for check and verification, as well as to obtain tangential bearings for the river, woods, hills, &c. There was no difficulty in thus managing the plateau; but the road and ravine from A to B could not be seen from it as soon as the Raven's Nest was passed. More assistance was obtained from the Wyndcliff and Black-wood Cliff, as regarded the road from St. Arvan's to Tintern, and the river,—but even here much had to be done by the tedious process of protraction, assuming that the left bank was inaccessible.

SECTION IV.

FIELD SKETCHING BEFORE THE ENEMY.*

It is of the first importance that sketches of ground required to aid in arranging the movements or positions of an army in the field should be made with the utmost rapidity: if not finished quickly, all the labour expended upon them is useless; therefore time should not be lost in making detailed drawings, as a rough sketch, if clear, is all that is necessary for this purpose.

To make the plan of a position, several officers may be employed at the same time, so as to complete it within a few hours: if a tolerably correct map of the country can be procured, one officer may be employed in laying down on paper the principal points, whilst the others are making the sketches on about the same scale, which he can afterwards put together. The scale of 4 inches to the mile will generally be found the most convenient for this purpose.

Each officer on coming to the ground should commence *at once* by laying down upon his paper the bearings of the most remarkable points visible from his station (which may generally be done sufficiently accurately † without instruments, and even

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* From Memoranda by Colonel Bainbrigge, C.B., Deputy Quarter-Master-General in Ireland.

† Only by those who have previously been well instructed and have had considerable practice. —*Ed.*

without dismounting), and at the same time the ground adjacent may be sketched in: the same must be done at his next station, the intersections of remarkable objects being always noted, and the whole operation carried on upon the same *principles* as those detailed in Section III.

It is not necessary to measure a base until in the course of the work a convenient place is found, as the bearings of the objects will sufficiently determine their *relative* positions; but a base might be paced by an intelligent Orderly to save time, and the best way to do this is to count only the alternate paces, or by double paces.

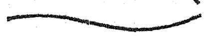
Where there is no accurate map available, the angles between the principal points may be measured by a pocket sextant, or by a compass. The covers of these instruments should always be attached to them by hinges, so as to serve as handles to them when in use.

The best touch for representing ground in the field is perhaps that of the vertical stroke, as the roads are thus better distinguished: the description of wood, marsh, &c., should be marked in writing.

The ground impassable for troops may be distinguished by the sign . . . . 

That impassable for any but infantry . . . . 

That passable for all but carriages . . . . 

Foot-paths may be drawn thus . . . . . 

Horse-paths thus . . . . 

Common car roads . . . . 

Great high roads . . . . 

The meridian line should also be drawn quite across the sketch: see those in Plate VIII.

All ground within cannon-shot (1200 yards) of the position on the flanks and front should be shewn, and the distances to the nearest towns should be marked on the roads.

The prominent points of ground must be numbered (if possible in red) in succession, to shew their relative commands, marking their approximate heights above the water or plain, or merely numbering them 1, 2, 3, 4, supposing differences of level of 30 to 50 feet (which must be specified in the margin) between them: all points where the horizon would cut as it appears from any station may be considered to be on the same level as it, and the proportionate heights of trees, houses, and animals, will aid in determining these levels.

It is through Colonel Bainbrigge's kindness that the writer of Sections I. II. III. is enabled to conclude this Paper by two specimens of Field Sketches, as actually executed by the above-mentioned Officer during the Peninsular war.

Plate XI. is the facsimile of part of a day's work *along a line*, in the neighbourhood of Tariego.*

Plate XII. and the following memoranda afford a complete illustration of the first paragraph of Section IV.; their interest is enhanced by their giving an account of how the sketch was made on which the Duke of Wellington took up his first position in the battle of Salamanca, on the 21st July, 1812.

* The rough original is on half a sheet of coarse foolscap, stitched to a letter from Aranda to General Alava, on the back of which last the sketching is continued.

Memoranda to accompany Plate XII.

" Dublin, 5th January 1846.

" Having been requested by the Editors of the 'Aide-Mémoire' to give a specimen of the sort of sketch of a position required during the Peninsular War, with an account of the mode of performing the work; the annexed, which I was required to make by his Grace the Duke of Wellington in Spain, is supplied accordingly; and the following is a statement of the circumstances under which that sketch was ordered, and the way I took to perform it.

"In 1812, when the French army, under Marshal Marmont, was crossing the Tormes, at Huerta, above Salamanca, before the forts of that place were taken, the Duke—at that time standing on the high ground in front of Cabrerizos, observing the enemy—desired me to cross the river, and see what sort of a position there was in a certain assigned direction, for stopping the advance of the French, and to make a sketch of it as quickly as possible.

" There were about two miles to ride to the ford of Sta. Martha, and perceiving at once that that point would be the left of the position, on having crossed, I began at the point A.

A. " The lines of direction to B, C, D, E, F, G, were first laid down, sketching in the river, the roads, the village, and particularly the church of Sta. Martha. These lines of direction were, in fact, so many angles laid down and protracted on the sketch, but no instrument was used, as there was no time: every thing was done by the eye. I did not dismount, and galloped from station to station.

C. " Having finished at A, I went along the road to Huerta (C), a farm of only two or three buildings, which was the only point to be seen in that direction from A; judging, then, this distance galloped over, the line from the church of Sta. Martha to C was assumed as the base.

" It was desirable that this front of the sketch towards Huerta should be done first, as the enemy's skirmishers were exchanging shots with ours between C and Pelobravo (M), when I reached that ground.

" C being fixed, the lines to H, I, J, K, L, M, were laid off; the line H intersecting the line B, shewed where the rivulet joined the Tormes. The line J, intersecting A E, shewed nearly where the steep fall of ground at J would come. The line L pointed out where the road to Calvarosa Abaxo crossed the rivulet, and to that point (N) I went.

N. " Here the angle between Sta. Martha and C was laid off, which fixed N, and then intersecting the lines I and K (taken from C), those two farms were fixed. The direction (O) of the stream was noted, and also the line to J was intersected; also a fresh object (P), a remarkable tree, was taken, as it was the only object between J and P, along the crest of what would obviously be the position.

Q. " The village (M) could not be seen; I therefore went to the rising ground (Q) from whence it was visible: at this point it was observable that I was in a line with the farm (K) and Sta. Martha church; then, assuming that line to be correct, the angle between Sta. Martha and C was laid down, which thus fixed Q. The next angle was that between C and M, by which the village M was fixed.

P. " Proceeding from Q, up the hill, to P, the angle was taken formed by N and Sta. Martha, which fixed P; it was also noticed that the line to the farm (I) passed to the right of the farm (K), which observation helped to correct the

sketch: also it could be seen that the line to H passed over K. The direction (J) was next taken, shewing the fall of ground and the direction of the road (D). There were no other points that could be fixed between D and the skirt of the wood (R).

R. " I then galloped to the top of the hill, and placing myself in a line with the two farms (I and K), that line was assumed to be correct; and then observing the angles between K and Sta. Martha, between K and C, and K and P, R was fixed.

" At R, I could see (over the trees) the village of Calvarosa Ariba, and also a chapel (called an Hermita) on this side of it, the directions to which were taken; also to the remarkable hill (S), and the abrupt slopes of the ground to the rear (U and V).

" A line was drawn to the fall, or gap, in the ground (T), taking great care that this, as well as those to S, Calvarosa, and the chapel, were as correct as possible in regard to the line from P, because the connection of the right of the position rested on this point, and the accuracy of the winding up of the sketch would depend on the correctness with which those angles were taken.

T. " Next to T; and as, on reaching it, it was clear that none of the points on the left of the posiiton could be seen, except R, it became necessary that the distance from R to T should be judged as accurately as possible—which distance became a fresh base. At T, thus fixed, all the right could be seen, and the Hermita could be intersected, as well as the ground to the rear (U, V, and E). The direction (X) of the smaller hill was taken, and the line over its summit, it was observed, passed to the abrupt right-hand slope of the ground (W), to the rear of the position. A farm also, in a hollow of some wood to the front, was also noted.

X. " I then went to the smaller hill, intending to go to the top, but the rocks were so rugged I could not ride up; so, standing on a line between it and T, at X, that station was fixed by observing the direction to E and to the Hermita.

" The line to Calvarosa from R was next intersected, which fixed that place. The direction to the houses (Z) was also laid down, and this place turned out to be the village of Arapiles; and the two remarkable hills were the celebrated hills of the same name.

" The line W being intersected, gave the boundary of the ground (Y): the farm in front, observed from T, could no longer be seen.

" Passing, then, down by the right and along the hollow between the two great hills, I went to the Hermita, and this point having been before fixed, from thence the direction of the further fall of the great hill (S) and two slopes of the hill on the further side of the Calvarosa valley were secured, as well as the direction of the water-course above and below. I then passed down the valley, and wound up the sketch at O.

" Going back from thence to C, I proceeded along the main road to D and E, putting in, on judgment, the village of Carvajosa, as well as the point F, where was a house, and where the great Salamanca road passed.

" I returned to Cabrerizos, finding the Duke where I had left him, and handed him the sketch, having been absent about two hours and a half. I made a verbal report to his Grace, pointing out the high hill (S), which we could plainly see from the spot where we then stood, observing that it was doubtful how far guns could be brought there, not having had time to ride thither.

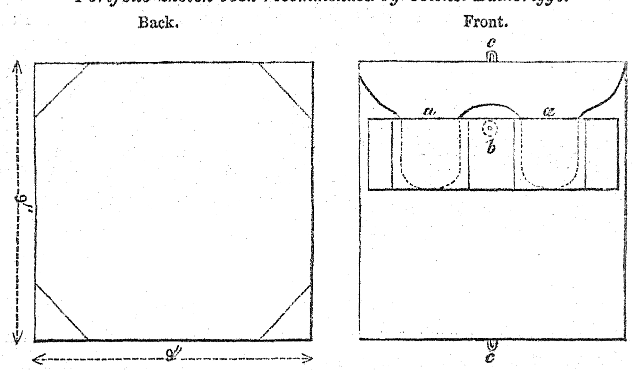
The Duke gave me back the sketch, to put it in ink, which I did, sitting down on the ground, and returned it to his Grace.

"In the afternoon of that day the position just sketched was occupied by part of our army; and the enemy having, by signal, communicated with the forts of Salamanca, re-crossed the Tormes at Huerta, and retired on the Douro.

"Some weeks after (July 21, 1812), this position was again occupied, but being too strong to be attacked in front, the French marched round it, and the battle of Salamanca took place next day, to the right of the ground here sketched—viz., to the right of the village (Z) of Arapiles. In making this, the sort of sketch-book was used given in the note below.—P. B."

R. J. N.

Portfolio Sketch-book recommended by Colonel Bainbrigge.



To be made of light paste-board, covered with some dark-coloured *parchment.*

a a. Flaps, so arranged to admit of the swivel (*b*) being placed as shewn: *b* may be a large button, the head inside.

A string passes through the eye, by which it is suspended from the neck. Some find an additional convenience in the loops (*c c*), through which also the string passes, and whereby it may be hung, when in use, en colporteur.

Sockets for pens and pencils, at the sides and along the top, within.

N.B. If larger than the above, it cannot be well concealed under the great coat, which is often indispensable.

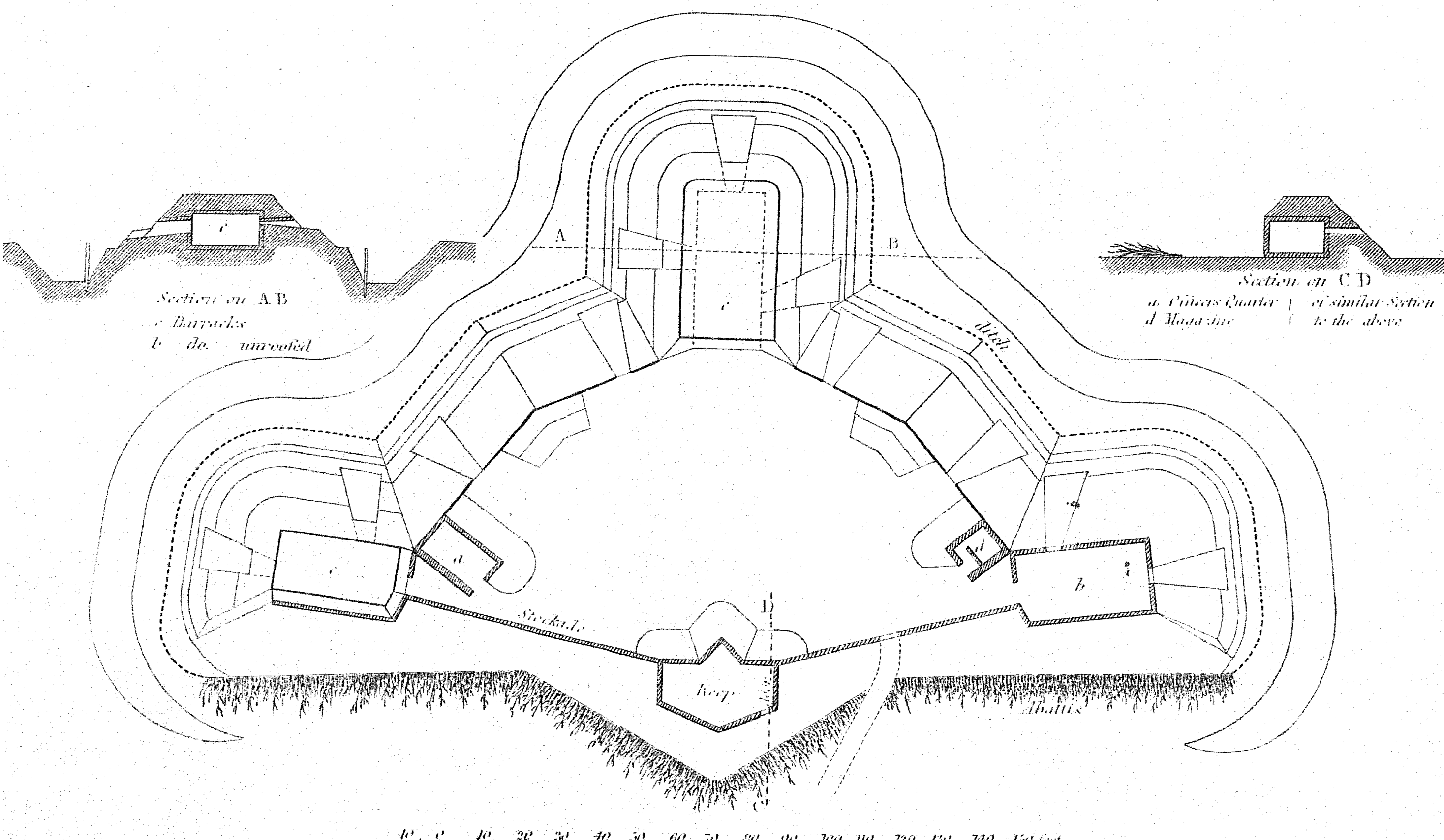
FIRE, VERTICAL.

A received, but indefinite expression, for practice with shot, shells, or stones, as fired from howitzers or mortars, though more generally from the latter.

For ranges and charges with these pieces, and their applications at Sieges, see 'Artillery' Tables E. F.; 'Attack,' pp. 92–95, and 'Breach.'

With reference, however, to the more restricted sense adopted by Carnot in his 'Defence of Places,' it implies the discharge of numerous small iron balls (weighing from 1 ℔. to 4 oz.) from mortars at an elevation of about 75°, to impede the progress of the attacks during the near defence.

It is more than likely that in the style of 'special pleading' in which Carnot wrote


Section on A B
c Barracks
b do. unroofed
Section on C D
a Officers Quarter } of similar Section
d Magazine } to the above
A
B
C
D
ditch
Stockade
Keep
Abattis
a
b
c
d
10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 feet

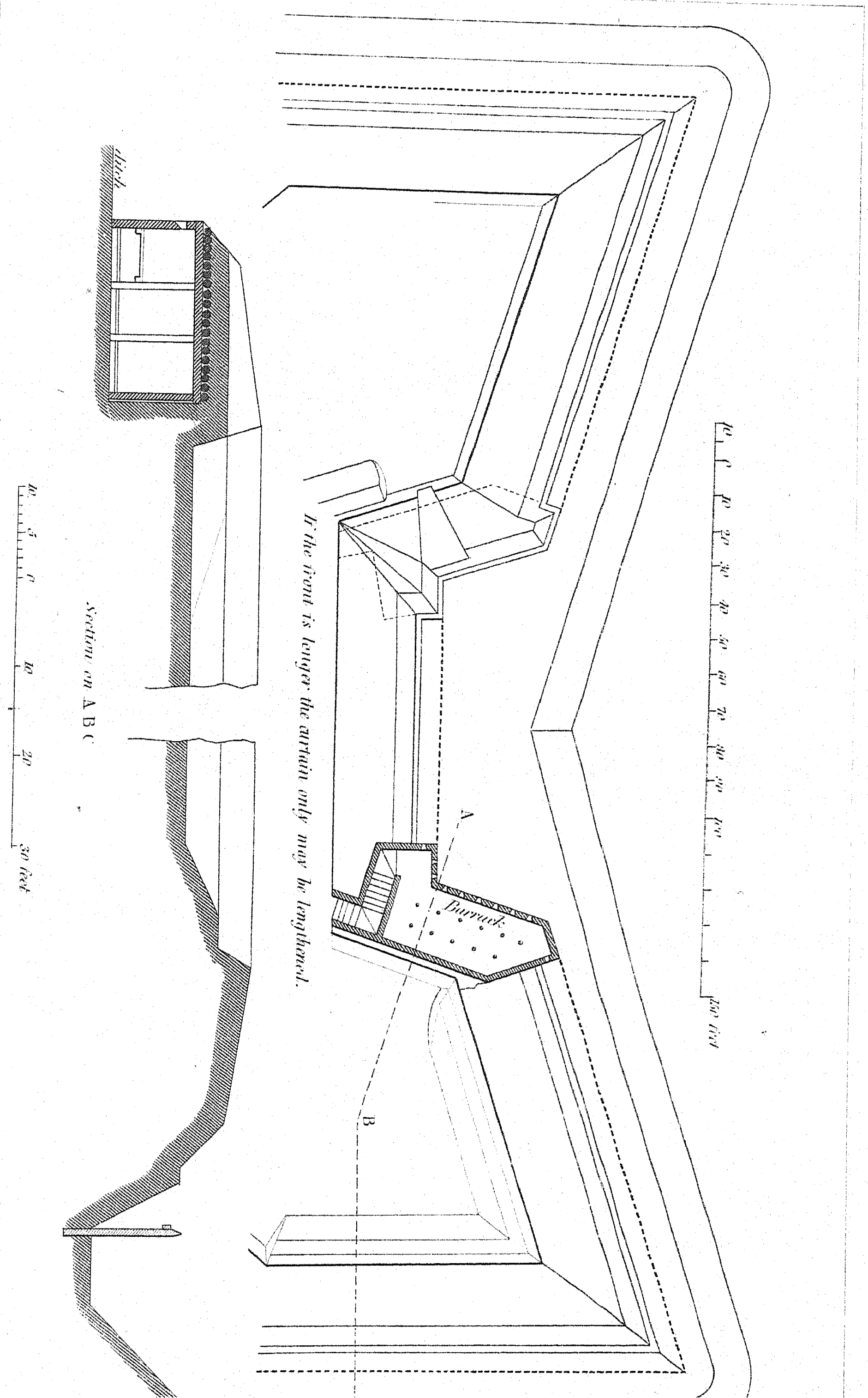
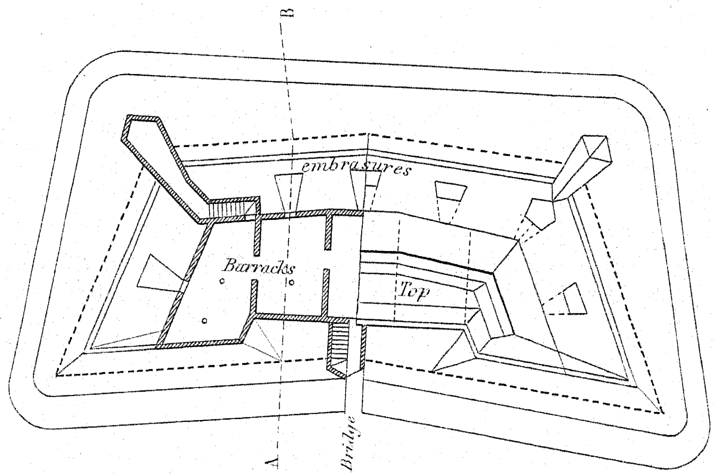
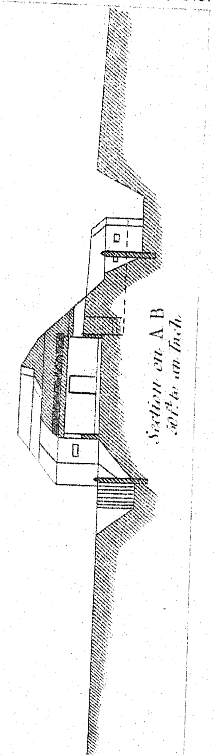

ditch
Section on A B C
30 feet
If the front is longer the curtain only may be lengthened.
Barrack
A
B
150 feet

Fig. 1.

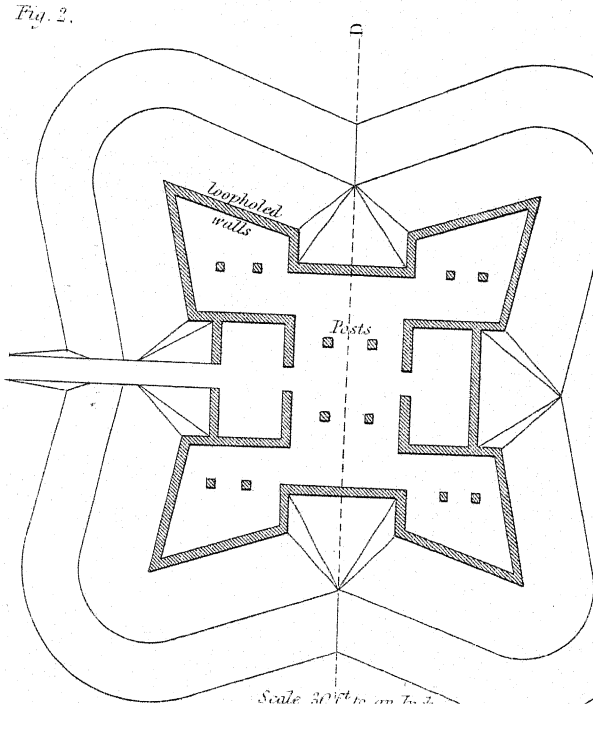


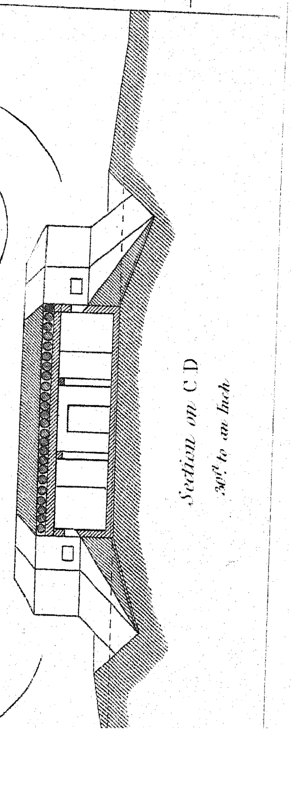


The outer thick dotted lines represent Palisades
The shaded parts shew the walls (of wood or stone)

Scale 50 ft. to an Inch

Fig. 2.





Scale 30 Ft. to an Inch

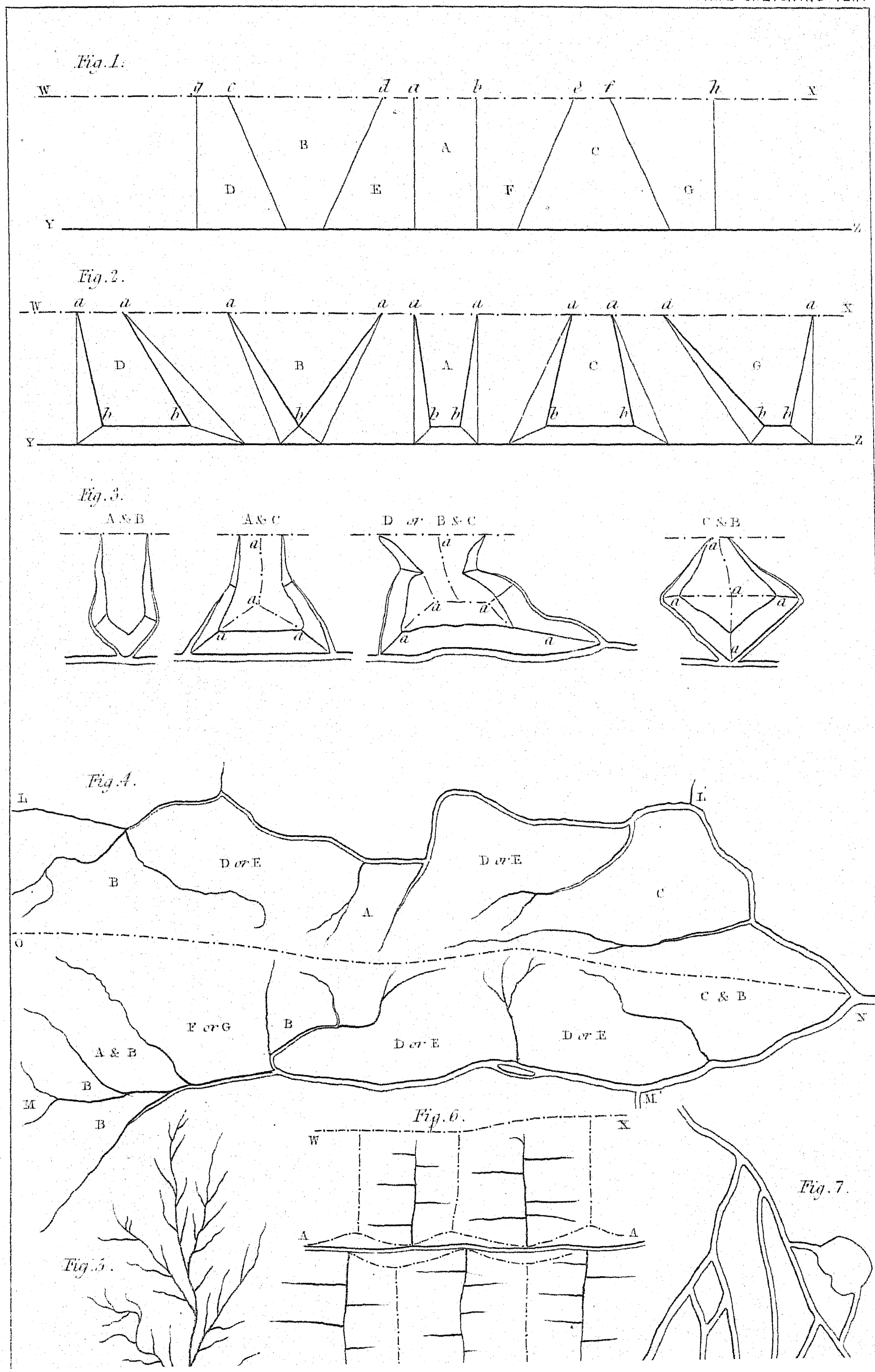
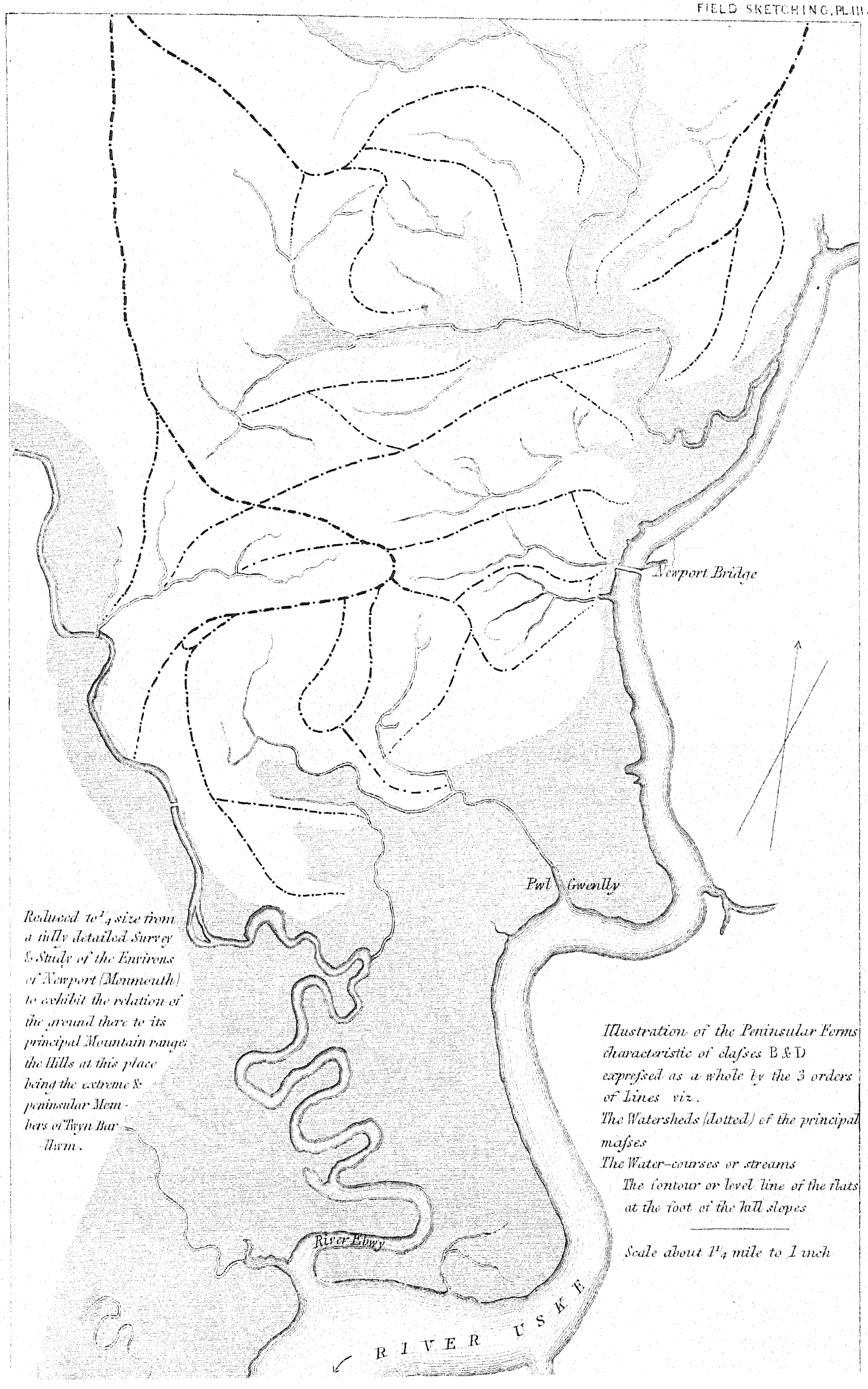


Fig.1.
W g c d a b e f h X
B A C
D E F G
Y Z
Fig.2.
W a a a a a a a a a a X
D B A C G
b b b b b b b b
Y Z
Fig.3.
A & B
A & C
D or B & C
C & B
a
Fig.4.
L L
D or E
D or E
B A C
O
F or G
A & B
B
D or E
D or E
C & B
N
M B
B
M
Fig.6.
W X
A A
Fig.7.
Fig.5.

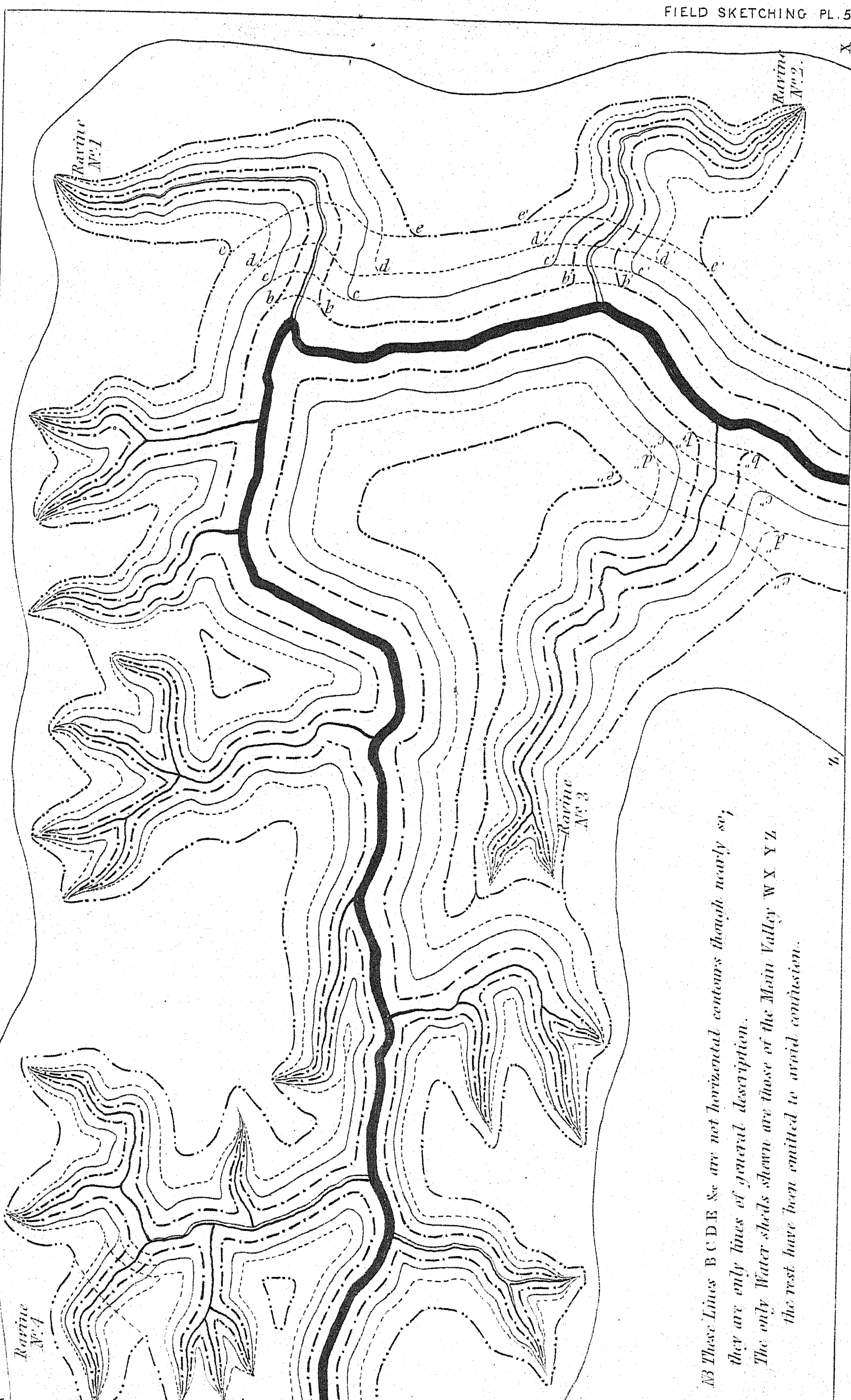
OUTLINE EXPRESSION

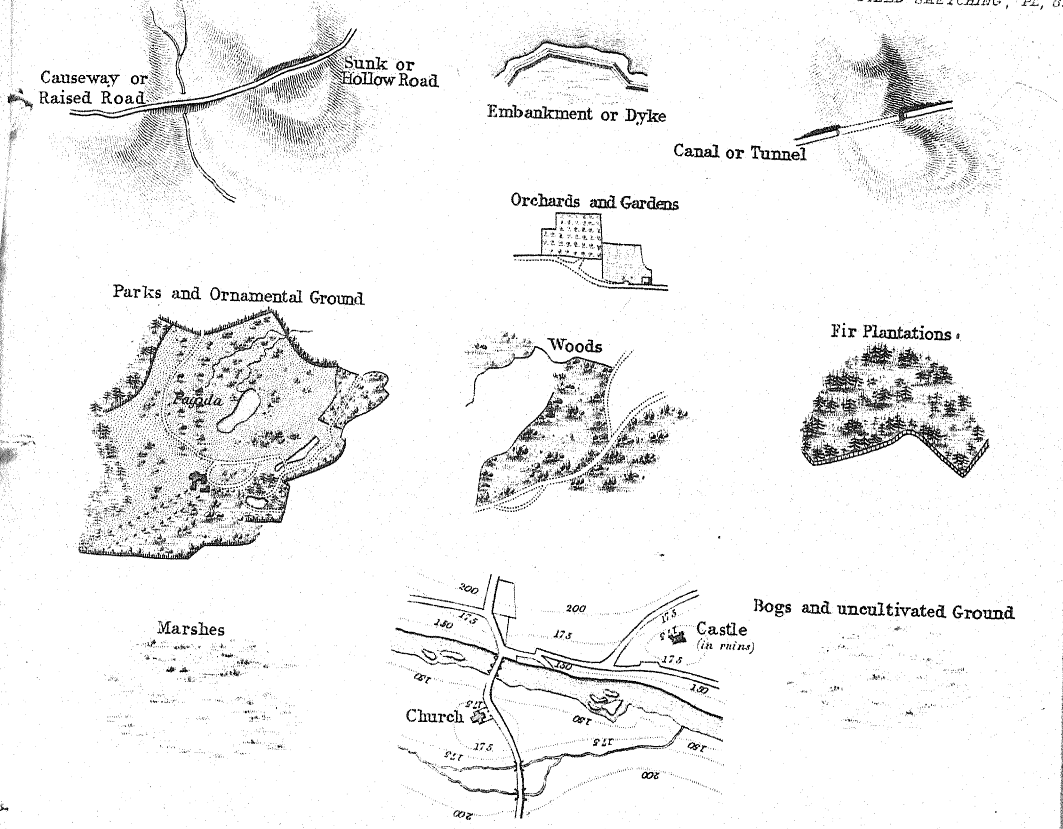
BY MEANS OF CONTOURS AND FEATURE LINES ONLY,
FROM A STUDY OF GROUND BY Mr DAWSON,
1825.

The Numbers 700, 500 &c. shew the heights of the hills above some assumed point.
The inclination of the slopes to the horizon are shewn by 10° 30° &c.


Newport Bridge
Pwl Gwenlly
River Ebwy
RIVER USKE
Reduced to 1/4 size from a fully detailed Survey & Study of the Environs of Newport (Monmouth) to exhibit the relation of the ground there to its principal Mountain range; the Hills at this place being the extreme & peninsular Members of Twyn Bar-llwm.
Illustration of the Peninsular Forms characteristic of classes B & D expressed as a whole by the 3 orders of Lines viz.
The Watersheds (dotted) of the principal masses
The Water-courses or streams
The Contour or level line of the flats at the foot of the hill slopes
Scale about 1 1/4 mile to 1 inch

Specimen of Contoured Ground in the County of Kilkenny.


X
Ravine No. 1
Ravine No. 2
Ravine No. 3
Ravine No. 4
E D C B A B C D E
Z
NB These Lines B C D E &c are not horizontal contours though nearly so,
they are only lines of general description.
The only Water sheds shown are those of the Main Valley W X Y Z
the rest have been omitted to avoid confusion.



Bleaching Grounds. Thin lines of the same length, nearly Parallel the whole colored Green.

Linen Manufactories.

Smithies. A small Horse Shoe with the open side turned towards the Road.

Limekilns.

Iron Works.

Glass Works.

Tanneries

Turnpike Roads. The side from the light shaded.

Cross Roads. narrower and both sides alike.

Rail Roads. both sides dark and perfectly parallel.

Canals. Distinguished from Roads by the parallelism of the sides the Locks and Bridges and by having the side next the light shaded like Rivers. Canals and navigable Rivers to be colored Bl...

Bridges.

Ford.

Ferry.

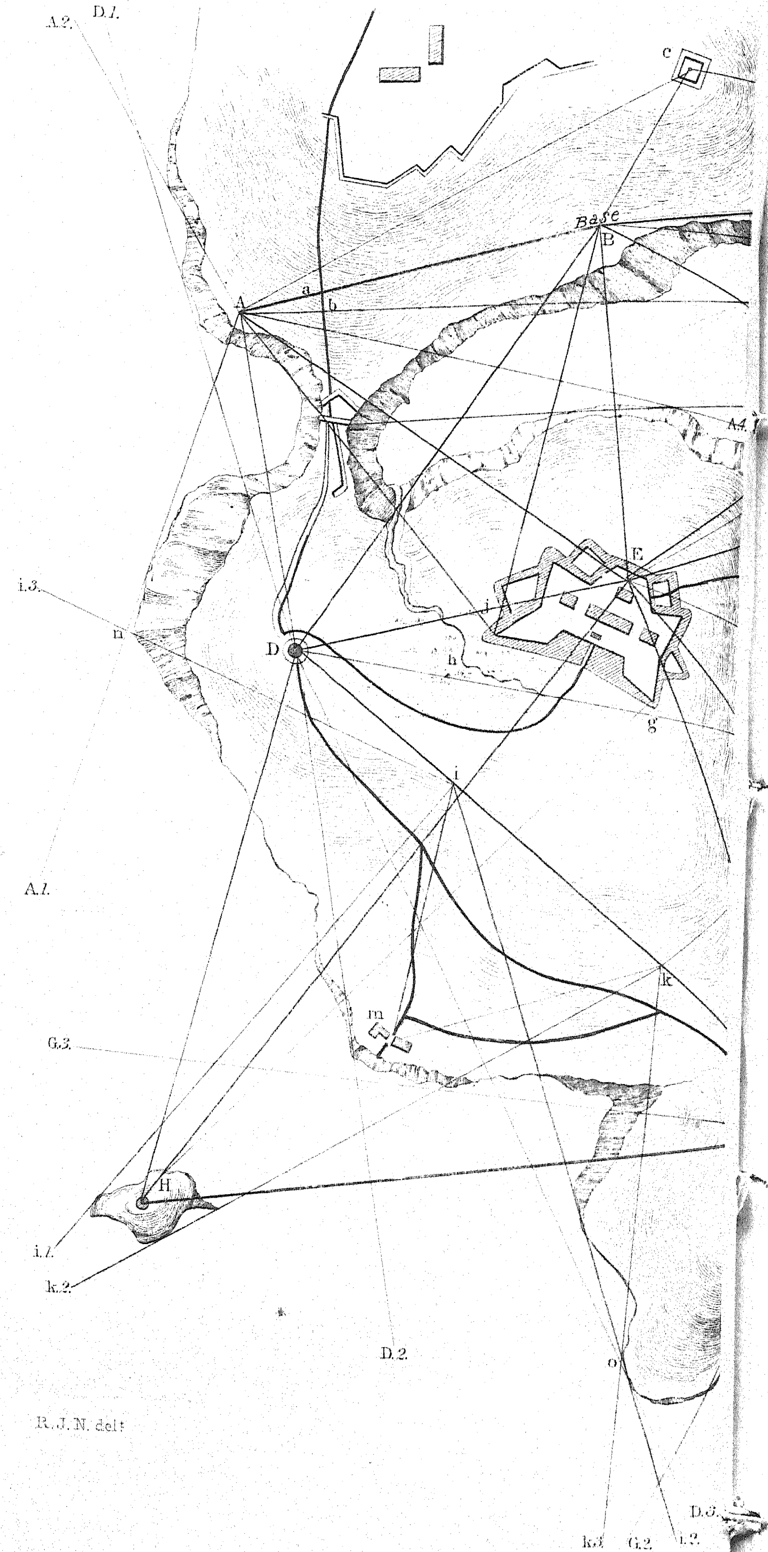
Fish Weir.

Mines:

- ☿ Mercury.
- ♀ Copper.
- ♄ Lead.
- ☽ Silver.
- ○ Gold.
- ♂ Iron.
- ♃ Tin.
- ⊖ Coal.

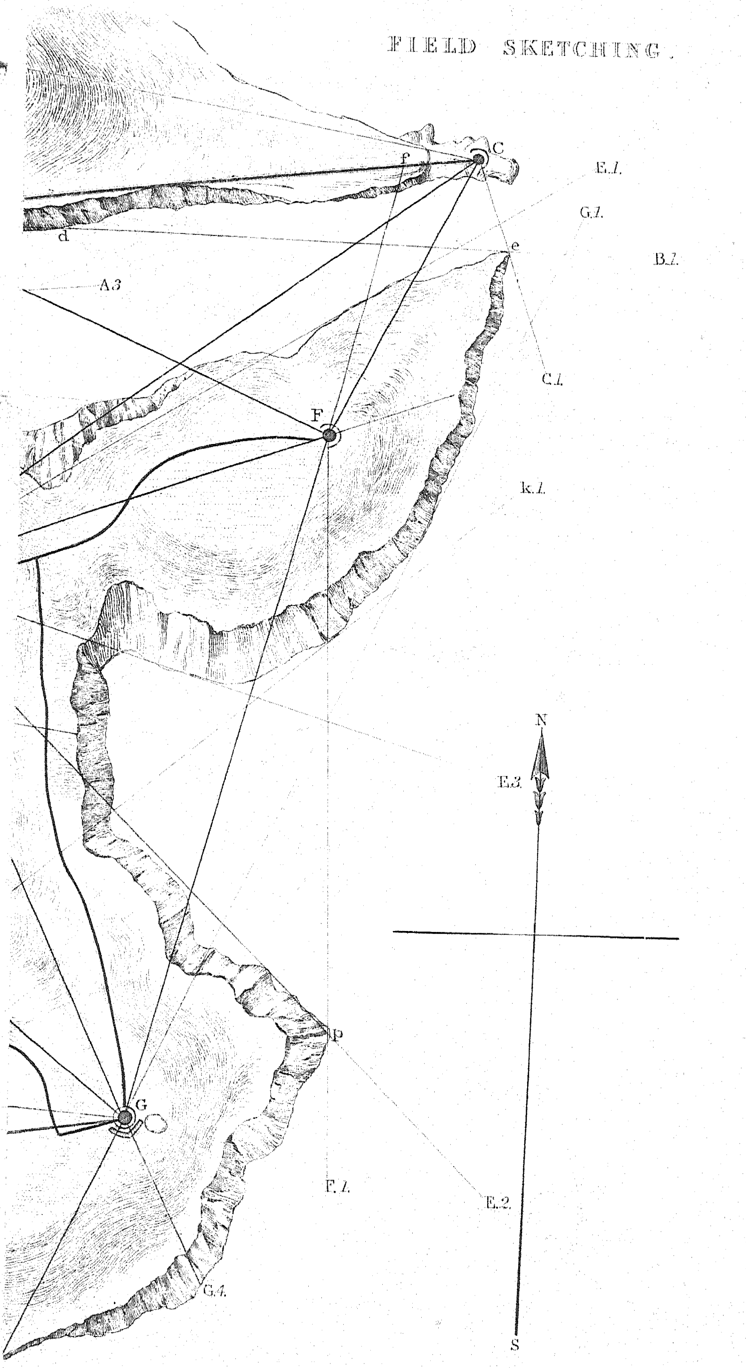
‡ Chapels.

Public House.



R. J. N. delt

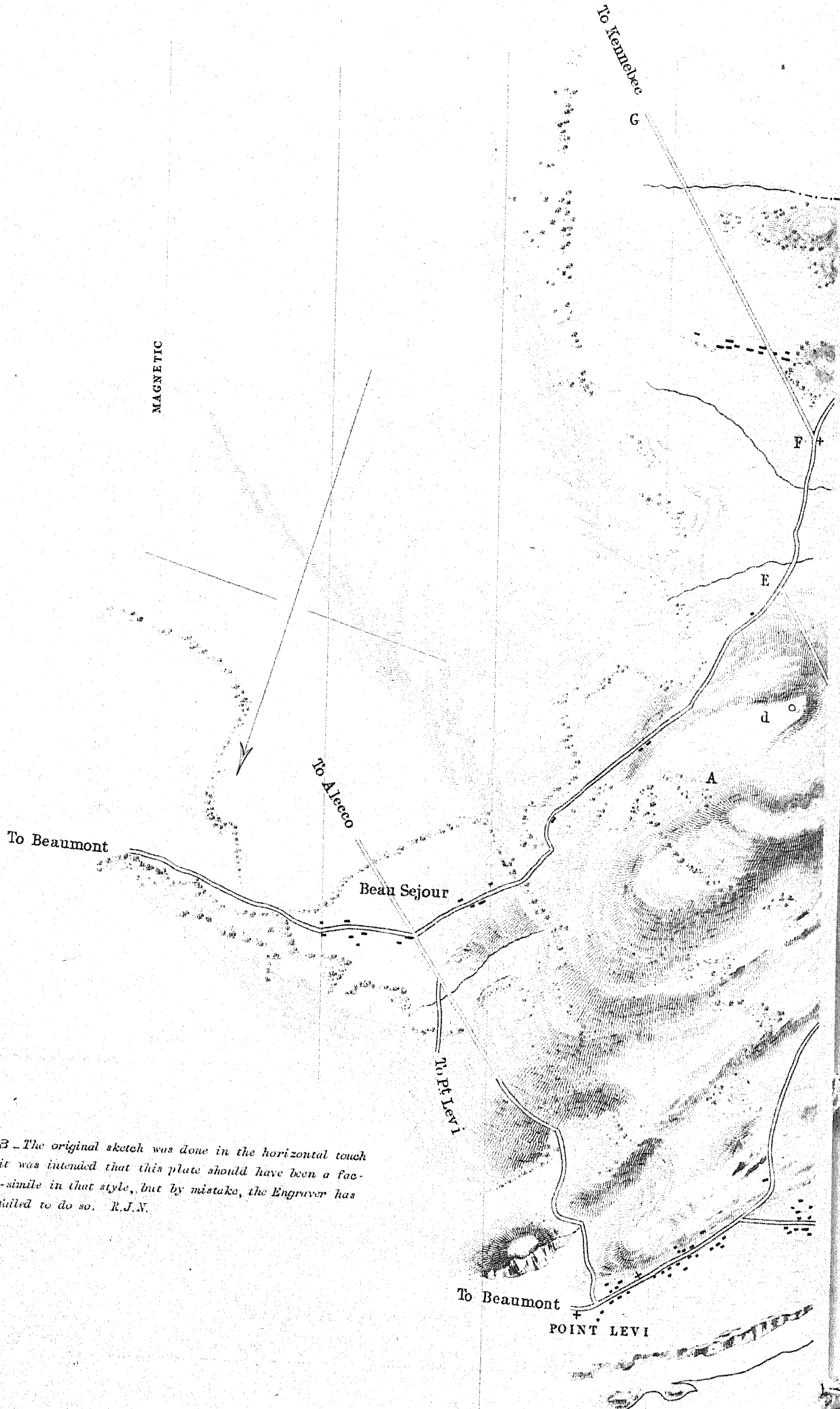
FIELD SKETCHING.



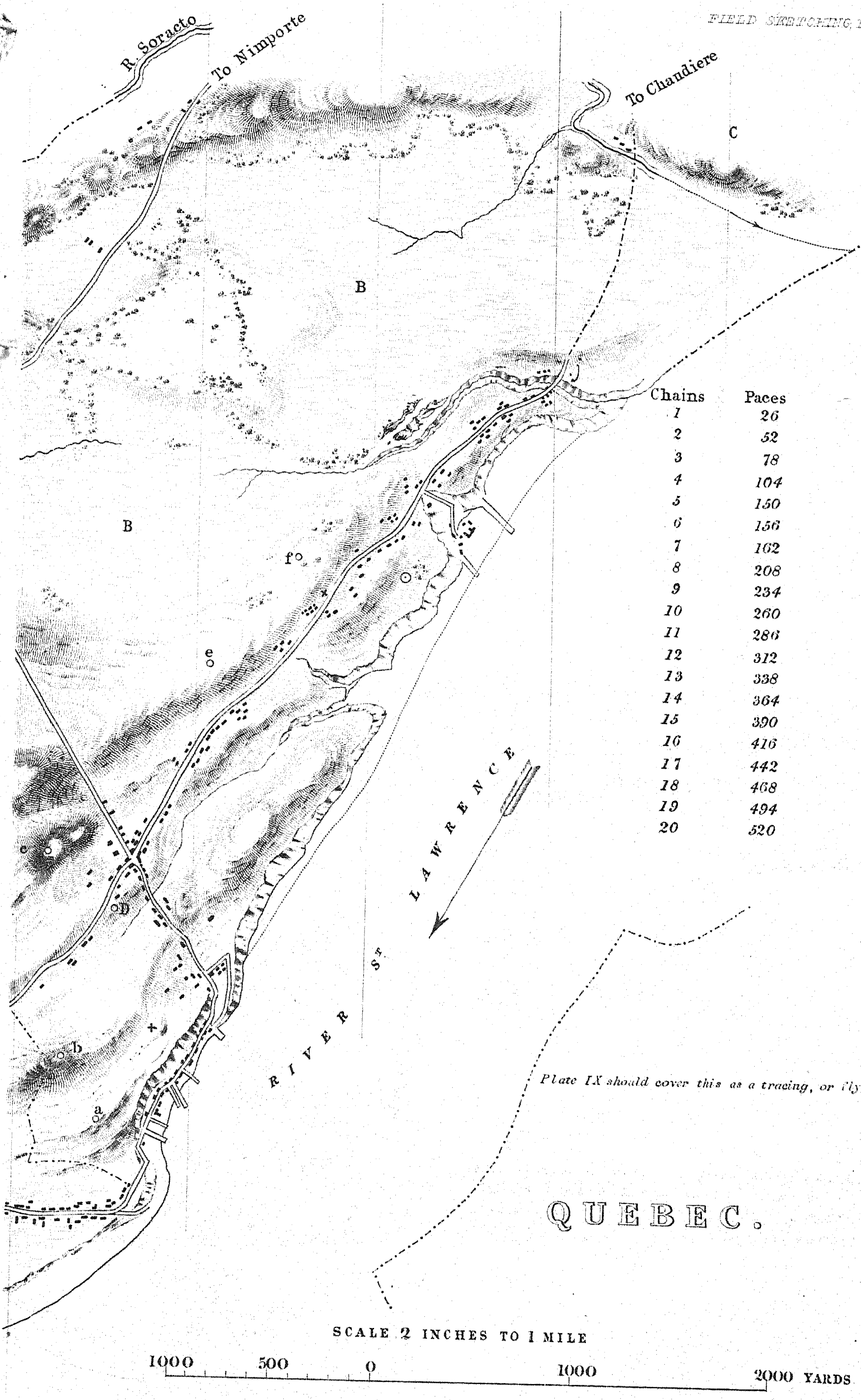
Scale — 6in. to 1 Mile.

C.R. sculp^t

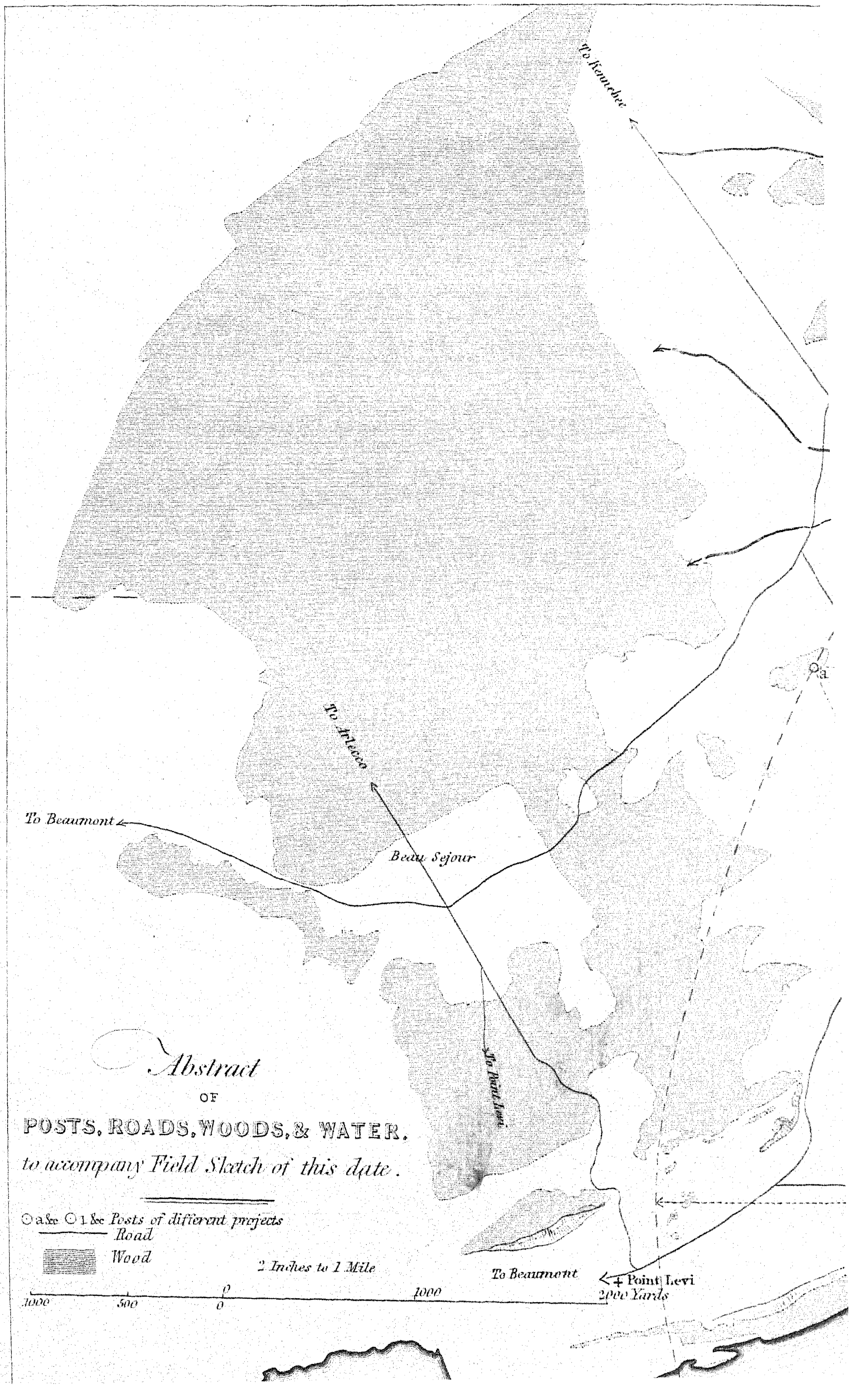
John Weale, 59, High Holborn, 1846.



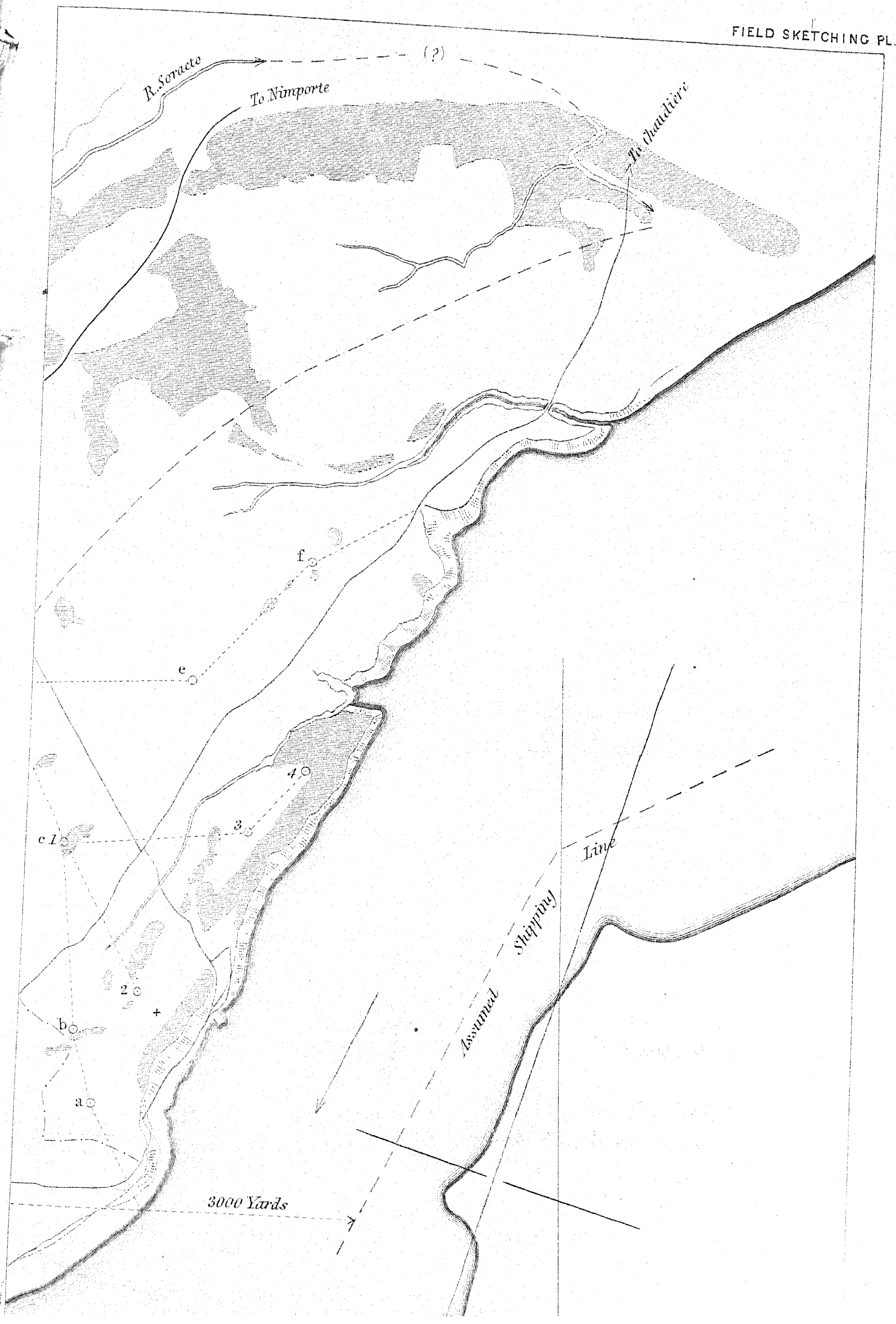
NB – The original sketch was done in the horizontal touch it was intended that this plate should have been a fac-simile in that style, but by mistake, the Engraver has failed to do so. R.J.N.



Chains	Paces
1	26
2	52
3	78
4	104
5	150
6	156
7	162
8	208
9	234
10	260
11	286
12	312
13	338
14	364
15	390
16	416
17	442
18	468
19	494
20	520



To Kennebec
To Beaumont
Beau Sejour
a
Abstract
OF
POSTS, ROADS, WOODS, & WATER.
to accompany Field Sketch of this date.
⊙ a &c ⊙ 1 &c Posts of different projects
Road
Wood
2 Inches to 1 Mile
To Beaumont
Point Levi
1000
500
0
0
1000
2000 Yards


R. Soracte
(?)
To Nimporte
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f
e
4
3
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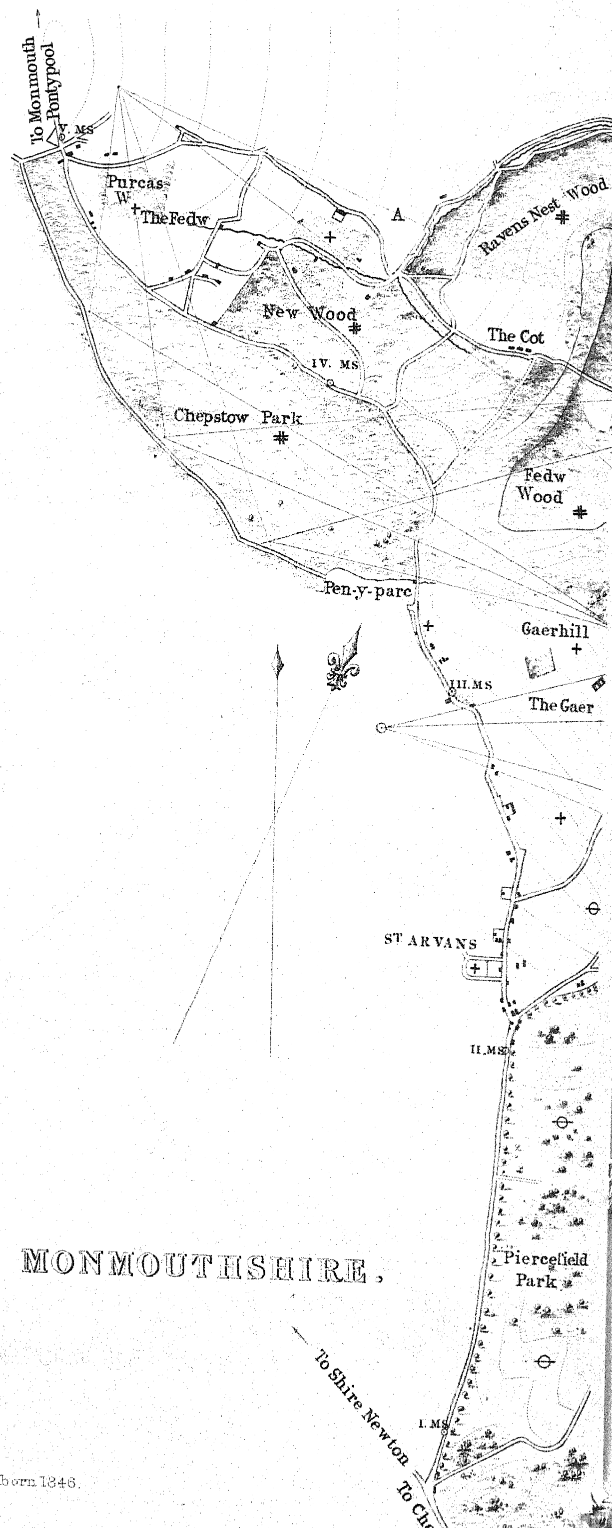
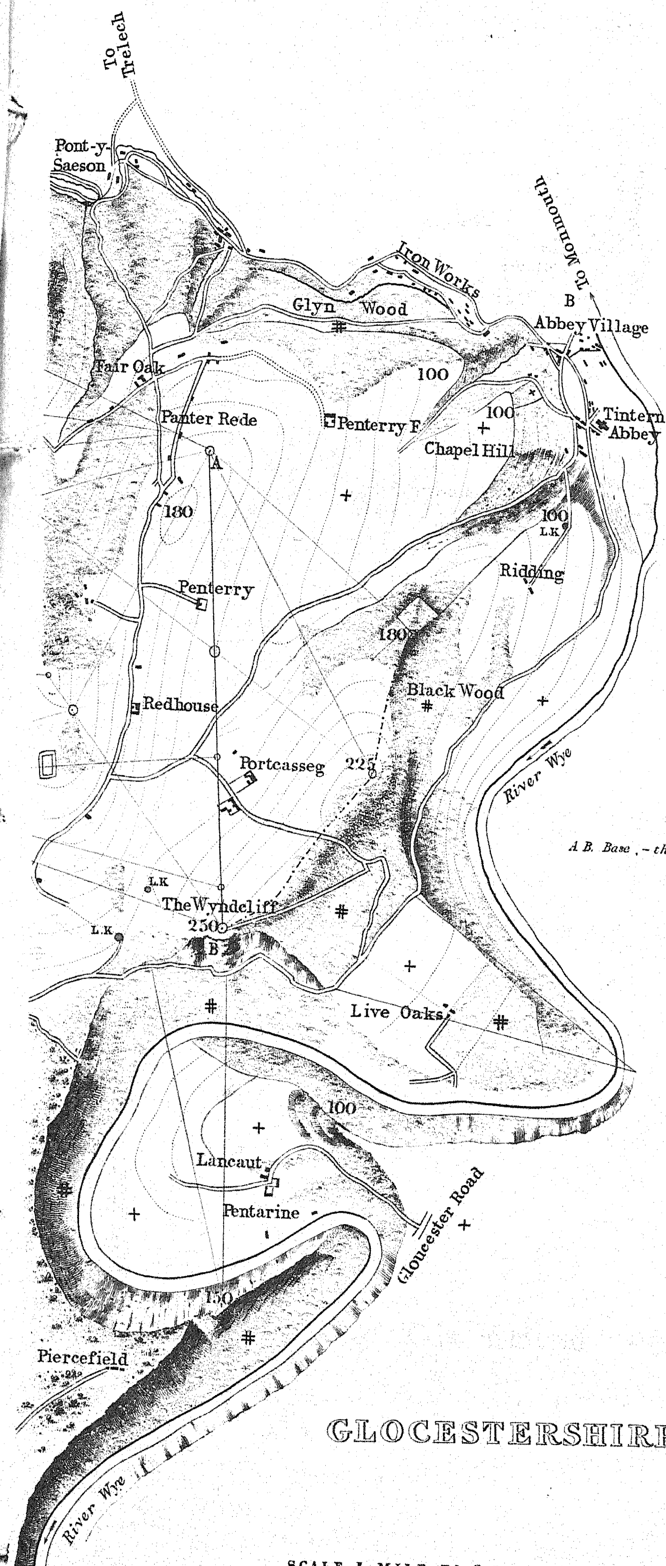
b
a
Assumed Shipping Line
3000 Yards



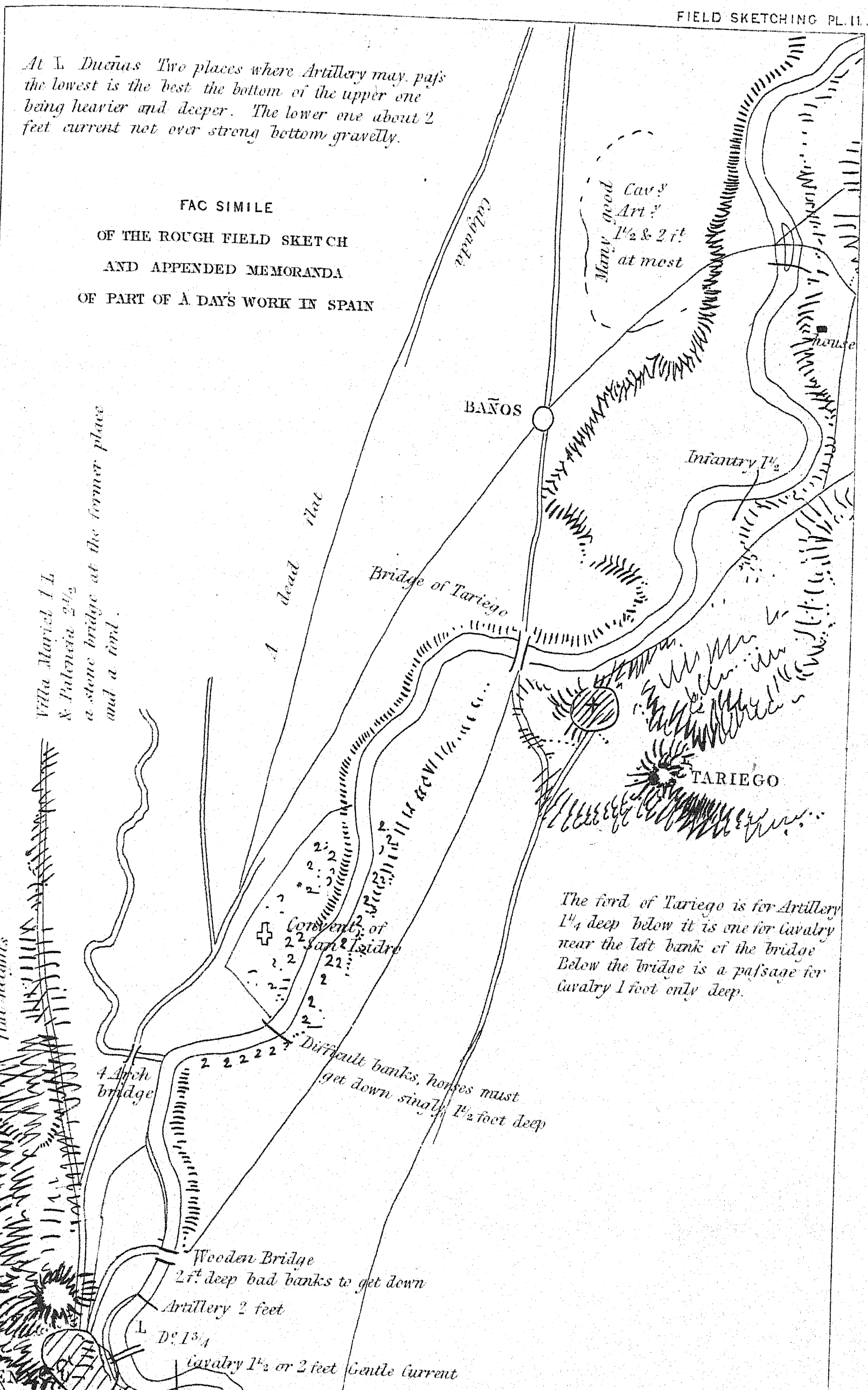
John Weale 59 High Holborn 1846.

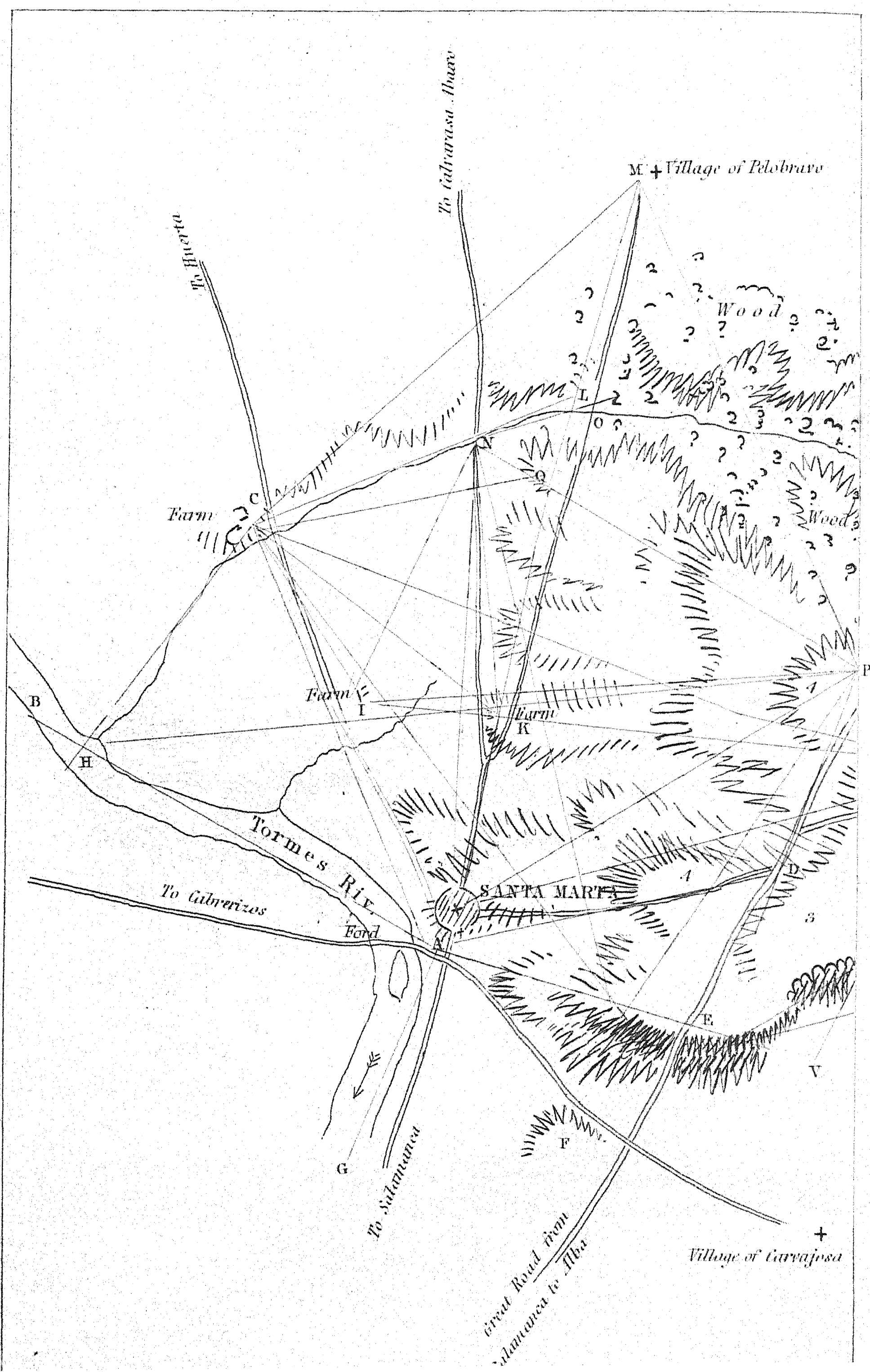


A B. Base, – the only one available.

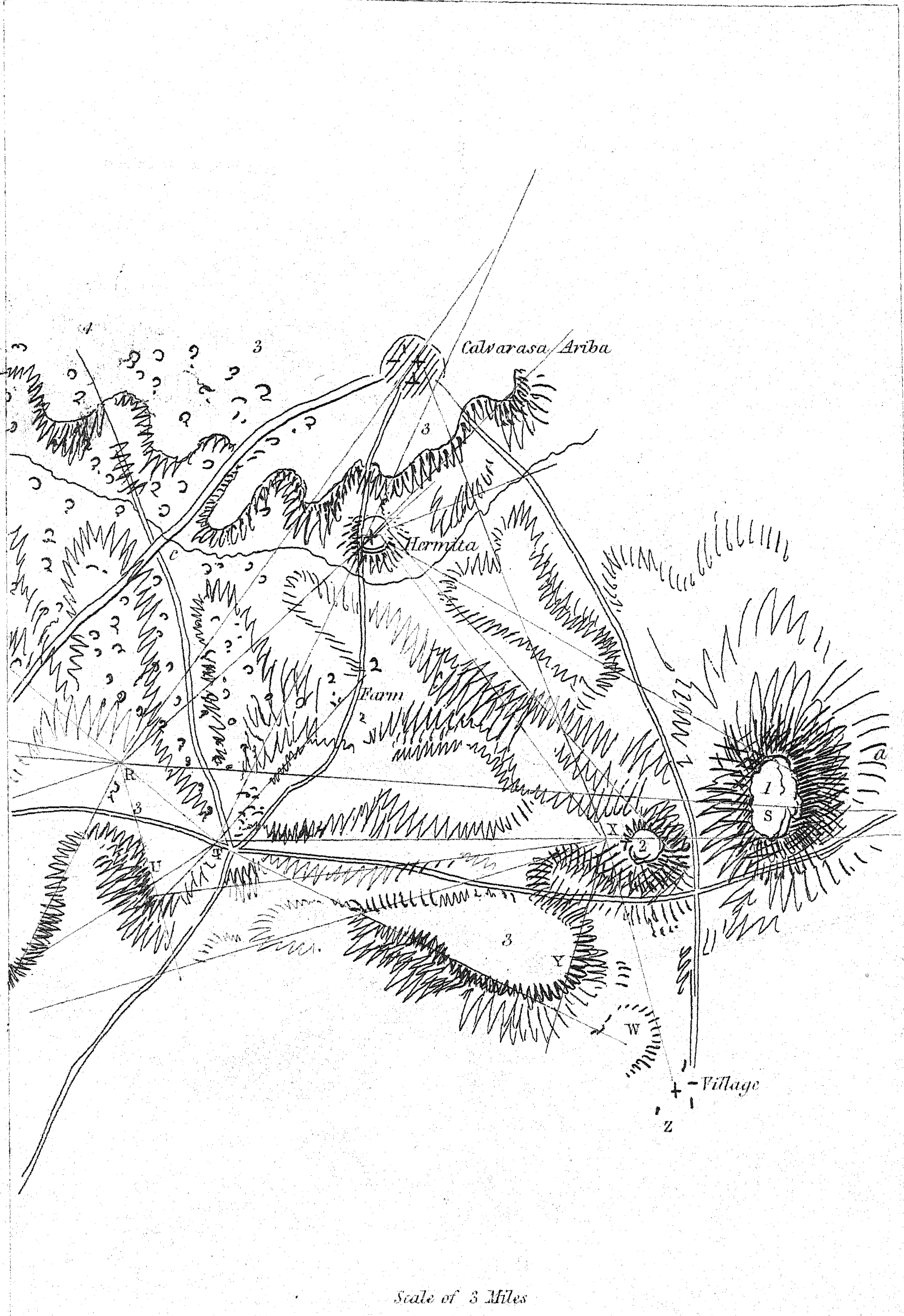
GLOCESTERSHIRE.

SCALE 1 MILE TO 2 INCHES


At L Dueñas Two places where Artillery may pafs the lowest is the best the bottom of the upper one being heavier and deeper. The lower one about 2 feet current not over strong bottom gravelly.
FAC SIMILE
OF THE ROUGH FIELD SKETCH
AND APPENDED MEMORANDA
OF PART OF A DAY'S WORK IN SPAIN
Calzada
Many good
Cav.y Art.y $1\frac{1}{2}$ & 2 ft. at most
house
BAÑOS
Infantry $1\frac{1}{2}$
A dead flat
Bridge of Tariego
Villa Muriel 1 L & Palencia $2\frac{1}{2}$ a stone bridge at the former place and a ford.
TARIEGO
The ford of Tariego is for Artillery $1\frac{1}{4}$ deep below it is one for Cavalry near the left bank of the bridge Below the bridge is a pafsage for Cavalry 1 foot only deep.
Convent of San Isidro
flat heights
4 Arch bridge
Difficult banks, horses must get down singly $1\frac{1}{2}$ foot deep
Wooden Bridge
2 ft. deep bad banks to get down
Artillery 2 feet
L
D.o $1\frac{3}{4}$
Cavalry $1\frac{1}{2}$ or 2 feet Gentle Current



M
Village of Pelobravo
To Calvarasa Abaxo
To Huerta
Wood
Wood
L
O
N
Q
C
Farm
Farm
I
Farm
K
P
B
H
Tormes Riv.
To Cabrerizos
Ford
A
SANTA MARTA
D
E
V
F
G
To Salamanca
Great Road from Salamanca to Alba
Village of Carvajosa


Calvarasa Ariba
Hermita
Farm
Village
R
U
X
S
Y
W
Z
a
c
Scale of 3 Miles
1
2
3

for particular purposes, he over-rated the merits of this arrangement; but in disproving his assertions, there is considerable reason to suppose that justice has not been done. Experiments were made at Woolwich towards the close of the war, in which the balls were received on sheets of wadmilltilt, which, from its toughness and elasticity, could have given no true indication of the real effect, although the opinions based on these necessarily deceptive results were for the time considered as decisive on the merits of Carnot's position.

The following experiments were made by the Bengal Artillery:* if such were the results at 45° elevation, we can form some estimate of what would have been given at 75°, with a suitable increase to the charge.

Mortars.	Elevation.	Charge. lbs. oz.	Number and Weight of balls.	Range. yards.	No. of Rounds.	Results.
13-inch.	45°	1 4	441—8-oz.	160-170	2	"Ranged compactly, none falling by the way."
Do.	Do.	1 6	900—4-oz.	Do.	1	"Fell in a pelting shower, rather beyond 170 yds."
Do.	Do.	1 8	900—4-oz.	Do.	1	Covered a space of 50 yds. long and 20 feet wide, "along the space that would have been occupied by an assaulting column."—"The whole space was paved with shot."
10-inch.	Do.	0 12	240—8-oz.			No further details given as to results, but they are stated to be of "like effect" with the above. "The balls appeared in the air like a flight of small birds, so close that the light could scarcely be discerned through the mass."
Do.	Do.	0 13	532—4-oz.			
8-inch.	Do.	0 6	114—8-oz.			
Do.	Do.	0 6½	228—4-oz.			

N. B. The balls were in canisters, and on a wooden bottom 3½ inches thick.

In addition to these, also, the writer of this Paper was present at some experiments in which only a Coehorn mortar was used; the elevation 75°; charge varying from 3 oz. to 4 oz.; thirty-six 4-oz. balls each round; range about 100 yards; and the object fired at was a space of 18′ × 18′, covered by four deal targets laid on the ground. The balls scattered so as seldom to hit the targets: of the few that struck, the penetration into the wood was from ⅛ to ¼ of an inch, *far* exceeding the utmost efforts of the strongest man of the party present, when flinging down the balls upon the target on which he stood, though he sent one through a felt cap.

The more scientific opponents of Carnot argue that no ball falling vertically can acquire a greater than the 'terminal velocity,' which is about 250 feet per second for a 1-lb. ball, and about 460 feet per second for a 42-lb. shot. Now the velocity acquired by the 4-oz. balls from the Coehorn could scarcely have exceeded 100 feet per second, yet no man could have stood its discharge for a moment. Referring to the 1-lb. balls as proposed by Carnot, and their terminal velocity of 250 feet,—at 300 feet per second the elm block of the ballistic pendulum just refuses admittance to an iron ball; but where is the head that would do so? The wounds and bruises received will be those of the very disabling and distressing character of a spent shot. It is submitted that this question merits reconsideration. R. J. N.

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* Communicated by Major Sandham, R.E.

FIRE, PRECAUTIONS AGAINST.

Our total failure in destroying the shipping at Antwerp in 1813–14 must be, in part, attributed to the measures taken by Carnot, who was then Governor. From such information as can be obtained, it would appear that they chiefly consisted in the establishment of well-organized fire-parties; and in securing the ships, by covering the decks with earth and dung, and supporting them by numerous props and stanchions.

What is given by Carnot, par. 47, 4th head of 'Defence of Fortresses,' may be combined with the following from Laisné. 2nd ed. p. 403.

"Lorsque la place est petite, ou ~~on~~ si toutes les troupes ne peuvent être logées dans les quartiers où elles soient en sûreté contre les projectiles de l'assiégeant, on ~~ou~~ *blinde*, autant que possible, les casernes les plus rapprochées du front d'attaque.

"Il convient surtout d'affecter à l'usage d'hôpitaux, les souterrains les plus sains et les meilleurs bâtimens à l'épreuve soit voûtés, soit blindés au moment du besoin.

"Les fours, les puits et les citernes doivent également être garantis contre les bombes, par des blindages, s'ils ne se trouvent disposés dans les locaux voûtés à l'épreuve.

"Pour diminuer les effets de la chute et de l'explosion des projectiles, on peut, dépaver les cours et une partie des abords de tous les établissements militaires.

"L'un des plus grands dangers dans une place assiégée étant celui des incendies, on devra organiser des compagnies des *Pompiers-bourgeois;* former des réservoirs d'eau multipliés, avoir 20 grandes échelles de 10^{m}. de longueur; 40 échelles moyennes de 7^{m}.; 50 petites échelles de 4^{m}.; 40 crocs ferrés gros et longs emmanchés; 10 pompes à bras; 350 seaux de cuir.

"On placera sur les clochers les plus élevés des *guetteurs* qui au moyen de cloches et de porte-voix, averteront du feu et des endroit où il éclatera. Ces guetteurs pourront en même temps, pendant la jour, observer les mouvements de l'ennemi, et en prévenir le gouverneur; pour cela, ils descendront leur avis écrits," &c.

Napoleon's decree, 24th December, 1811, article 94, relative to the defence of places, was, "Le Service d'Incendie, en cas de siége, ou de bombardement, est reglée par le Gouverneur ou Commandant, de concert avec le Commandant de Génie et l'autorité civile."

It is to be observed that when a dockyard, in which there are several ships, either in dock or on the stocks, tolerably near one another, is once thoroughly on fire, no hitherto arrangements in the way of ordinary fire-engines are of the *slightest* use. Dockyards should be provided with reservoirs with the requisite *steam power* arrangements for their supply, rather from the sea* than from the common limited resources of water-companies: the head of water thus given, and led amongst the shipping, should be such as will pour *volumes*, not petty jets d'eau, as from common fire-engines, that do but aggravate the fierceness of the combustion by their insignificant streams, and embarrass all extensive arrangements by the confusion and interference of their numerous working parties with those employed in the removal of the neighbouring materials, &c.

The writer was on duty at the fire in Devonport Dockyard, in 1840: as long as the flames from the ships, their sheds, and the neighbouring piles of plank and timber,

* Salt water freezes far less readily than fresh,—hence an additional reason for availing oneself of this resource in countries near the sea, when the cold is severe and the pipes soon frozen.

were at all inclined to advance, though driven on by only the very light wind of that morning, the engines could only retire, as it was *impossible* to face the heat: it was only when the providential change of wind (the only thing that saved the yard) sent the fire back over the ground it had imperfectly cleared, that the fire-engines could be at all satisfactorily employed. One great cause of danger, in such cases, lies in the extraordinary height and distance to which pieces of burning wood are lifted and carried by the slightest zephyr, that when untouched would require a gale to move them along the ground: when fully ignited, the volume of rarefied air around them evidently gives them the buoyancy of a fire-balloon.

In extinguishing fires in towns, an Engineer will act wisely to avoid having any thing to do with them, unless on a distinct understanding with the municipal authorities that his directions are to be implicitly followed, and that the police assist in keeping the ground clear. When there is a military party co-operating, the task is far more likely to be satisfactory. The first thing to be done is to plant lines of sentries to keep off the mob, allowing no one to pass but such as are called by the police: lines of men should also be formed to the nearest pumps and wells, to pass on buckets, either to feed the engines, or be thrown on the flames. Orders being given to this effect, the Officer will, in general, save time by reconnoitring the building outside and inside, quickly, before he posts the engines, or takes other measures. Possibly some arrangements will have been made by others before he arrives, and in this case, where disturbing such may be unadvisable, even to afford a better application, it is of consequence to feel, "It is too late to do what I wish,—I will do the best with what remains to be done;" and then act with decision and energy. In making examination inside, he may often creep on hands and knees, along passages and into rooms, breathing freely, where he could not stand upright half a minute without suffocation.

There are no tools, on such occasions, like the crow-bar and felling-axe; the former for knocking holes through walls, to make short lines for passing the hoses; and both, for destroying floors, partitions, &c., especially such as are in any way connected with or composed of lath and plaster, where fire lurks in a way not easily conceived by those who have not seen it.*

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† "The intensity and consequent danger from fire is (cet. par.) as the cubic contents of the building in which the fire takes place.

"In warehouses or stores, where large quantities of combustible goods are kept, floors of brick arches, supported by cast iron pillars and bearers, are no protection, as the heat is sufficient to fuse the cast iron, or to weaken it, so as to render it unable to bear the weight and strain of the arches. The heat also expands the iron to such an extent as to unsettle the brick-work: the wrought ties also become useless from expansion and losing their rigidity.

"These remarks do not apply to dwelling-houses, as the use of cast iron bearers reduces the quantity of timber so much, that if there is nothing kept in the house, with the exception of the usual quantity of furniture, it is not likely that the heat will be great enough seriously to injure the cast iron, if sufficiently strong originally, which is not always the case.

"Sheet iron nailed over timber is no protection against continued heat, but only against flame for a short time.

"Several buildings have been set fire to by the use of iron hearths.

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* For notices on the use of powder in fires, see 'Demolition,'—buildings.

† From a letter with which the Committee were favored by Mr. Braidwood (68, Watling Street), Superintendent of the London Fire-Engine Establishment.

"Wherever a wall can possibly be carried through the roof, it is the best protection against fire, even if there should be openings in the floors below. When a fire takes place, the heated air and smoke rises immediately, and fills the roof and upper floors, causing the materials to give off gas, which takes fire as soon as the fresh air is admitted below to carry up the flame.

"In extinguishing fires, the first point is, to keep the building where the fire is, as much shut up as possible, till the engines, or other means to extinguish it, are ready for use, and then to get inside the building on fire: if this cannot be done, it is generally expected that the building will be destroyed, and in that case greater attention ought to be given to the adjoining premises. When an engine is sent to a fire here, the usual number of firemen is four besides the driver: these men are employed first in attaching the hose and suction, and then in directing the jet and the working of the engine: the mere manual labour is performed by the mob, who are paid at the rate of 1*s.* for the first, and 6*d.* for each succeeding hour."

EXTRACTS FROM THE "GENERAL REGULATIONS FOR THE LONDON FIRE-ENGINE ESTABLISHMENT," CONSISTING OF EIGHTEEN OF THE PRINCIPAL INSURANCE AND OTHER PUBLIC COMPANIES.

Organization.

London is divided into five districts, three on the north of the Thames, two on the south, in each of which is stationed a sufficient number of engines, under the charge of a Foreman, with Engineer and Firemen under him. The Superintendent has the command of the whole force.

The men are clothed uniformly, are distinguished by numbers, and are regularly exercised in the use of their engines: their whole time and service belongs to the Establishment.

General Memoranda.

"To execute their duties as *steadily* and *quietly* as possible; to be careful not to annoy the inhabitants of houses they may be called upon to enter; to treat all persons with civility; to take care to preserve *presence of mind and good temper;* and not to allow themselves to be distracted from their duty by the advice or directions of any persons but their own officers."

Conditions of Service.

"The age of admission of men to be, Engineers not exceeding 50, and Firemen not exceeding 40 years. Not exceeding 25, nor under 18, for men who have not previously been Firemen. Pay varies for Firemen from 21*s.* to 24*s.* 6*d.* per week; the Engineer and Foreman 28*s.* per week. Foreman of Districts 1*s.* per week extra for every engine under his charge. Uniform is found by the Establishment."

Outline of General Duty.

"One-third of the men to be on duty night and day at the different engine-houses —the whole to be liable to be called up for attendance at fires, or for any other duty." On a fire breaking out, the whole of the men of that district, $\frac{2}{3}$rds of the collateral, and $\frac{1}{3}$rd of the flank district, are to be in attendance; also 1 engine from collateral district, and 1 from one flank. In case of doubt as to boundary, both adjoining districts send all, and the remaining three send $\frac{1}{3}$rd. In case of emergency the Superintendent will call in such additional force as he may require. The engines will be conveyed to fires at not less than 7 miles per hour, and the men who do not accompany the engine at not less than 5 miles per hour."

Foreman.

"He will be careful to place the engine in such a manner that the men who work at the levers may be in no danger from the falling of the premises on fire; and also that the engines may not be in the way of people carrying out furniture, &c.; but above all things he will endeavour to place the Engineers with their branch-pipes in such positions *that the water from the branches may directly strike the burning materials:* this he cannot too often inculcate on the men placed under him, as upon this point being properly attended to depends entirely the effect of the engines. To attain this most desirable end, it will be frequently necessary to enter the premises on fire; and the Foreman must take care so to place his men that they can easily escape. If he has reason to suspect that the building is not sufficiently secure, he will station one or two competent men to observe the state of the building, and to give the alarm when they see any danger. He will never allow any man unaccompanied by another to enter a building on fire. He will not throw more water on the premises than is absolutely necessary to extinguish the fire, as all that is thrown on after the fire is extinguished only tends to increase the damage.

"*When the inmates of the premises on fire are removed,* the Foreman will endeavour to exclude air from the parts on fire, by shutting all doors and windows as far as may be practicable." *

"He will be responsible for the engines in his district being each provided with the articles contained in the following list:

2 lengths of scaling ladder.
1 canvass sheet with 10 or 12 handles of rope round the edge of it.
2 pieces of 2½″ rope, one 10 fathom and one 14 fathom long.
6 lengths of hose, each 40 feet long.
2 branch-pipes, one 2½, and the other 4 to 6 feet long.
1 spare nozzle to ditto.
2 lengths of suction-pipe, each about 6 feet long.
1 flat rose.
1 goose neck.
1 stand cock.
2 balls of stripes of sheep-skin.
2 balls of small cord.
2 dog-tails.
1 dam-board.
1 boat-hook.
1 mattock.
1 shovel.
1 saw.
1 screw-wrench.
1 portable cistern.
1 hatchet or pole-axe.
1 crow-bar.
Instruments for opening the fire-plugs, and keys for turning the stop-cocks of the water mains."

FIRE CART.

Notwithstanding all that system can effect, much precious time, *in first moments,* is consumed before the Establishment of fire-engines in our dockyards and arsenals can be brought into play in case of fire. The following practice obtains in the Devonport Dockyard; and whether the fire has broken out in the yard or not, an invaluable assistance is promptly on the spot, before most or any of the Fire-Office engines, or those of the neighbouring barracks, are well in motion.

A large strong cart is fitted up to carry either the engine,—or else the party, with the engine dragging behind.† The best kind of cart is that which (with wheels of the

* This paragraph is printed on the cards delivered to the police:—the pocket-book from whence the above memoranda are taken is given to the firemen only.

† For short distances only, when thus dragged behind: in the preceding paragraphs, notices are given of the London engines as so mounted as to be equal to any reasonable distance.

usual size) is slung very low on a crooked axle, as in the description called 'ducks' at Woolwich, and 'floats' in Dublin. Two horses are always at hand, with a strong but very simple harness, besides saddle, whip, and spurs, for the driver, who goes as postilion.

Attached to the engine are as many buckets as can be conveniently hung; the hoses are coiled away on the top of the well; the branch-pipe and suction-hoses lashed to the side of the body; a double screw-box (one end fitting the town pipes, and the other those of the dockyard), wrenches, hammer, spare leather washers, &c., &c., are in a small box; two or three coils of 2½-inch rope, of 50 yards each, (for fire-hooks, and letting down persons from windows,) and a coil of 50 yards of 1¼-inch line for passing hoses and stores: both sorts of rope should be well worked till rendered soft and pliable. Fixed to the sides and ends are 2 felling-axes, 2 sledge-hammers, 2 crow-bars, 2 shovels, and 2 pickaxes, as well as the drag-ropes, and extra purchases. The cart is fitted with a cross bar in front, by which the party hold on when they are carried: to the ends of this bar, sockets for a pair of carriage lanthorns are fixed. At convenient points on the sides and ends (inside and out) are hung the buckets, 2 short ladders, (capable of being joined like escalading ladders?) and the tools above-mentioned, the points and edges of which last must be guarded when they are inside the cart, to prevent injuries to the party in the dark. The men, as a matter of course, are provided with leather helmets, gauntlets, and screens for their faces, like those worn by blacksmiths. As thus arranged, an Officer* and party have started well *within* 10 minutes after the alarm was given.

It may be advisable to add to the above a copper-covered chest fitted with powder-bags, portfires, &c., principally for the purpose of cutting off a mass of houses irrecoverably on fire, by the rapid destruction of a line of intermediate buildings.

R. J. N.

FORAGE, BULK AND WEIGHT OF.—From measurements taken expressly for this Article.

Hay in flat and tolerably square bundles, as usually delivered	4¼ lbs. per cub. ft. Trusses supposed to weigh 56 lbs., but varying from 52 to 58 lbs.
Straw, in flat and tolerably square bundles, though not so compact	$3\frac{1}{10}$ lbs. per cub. ft. Trusses supposed to weigh 38 lbs., but varying from 30 to 40 lbs.
Oats, new	3·64 cub. ft. per cwt.
Barley, do.	2·38 " "
Wheat, kiln-dried †	2·36 " "

Of course considerable allowance would be made, in providing space for forage, on the above quantities.

The ration of forage for Artillery and Cavalry, at home, is

Oats	10 lbs.
Hay	12 "
Straw	8 "

R. J. N.

---

* Lieutenant Williams, R.N., by whom the above was contrived and executed.

† Inserted here as matter of convenience: raw wheat is somewhat lighter.

FORDS.*

In examining and reporting upon a ford, the main points to be considered are the firmness and regularity of the bottom, its length, width, and direction, the depth (and its increase by tides or floods), the rapidity of the current, the facilities of access, security from attack, and the means of rendering it impassable: a ford should always be tried personally before making a report on its capabilities.

The *depth* of fords for cavalry should not be more than 4 feet four inches, and for infantry 3 feet 3 inches; but if the stream is not very rapid, and the direction of the crossing is down-stream, the latter may pass by holding on to the horses, even if the depth is four feet. Should the stream be very rapid, however, depths much less than these could not be considered fordable, particularly if the bottom is uneven. Carriages with wheels 5 feet in diameter may cross a ford 4 feet deep; but if it is necessary to keep their contents dry, the depth should not be more than 2, or at most $2\frac{1}{2}$ feet. Fords are generally to be found above or below a bend,† and often lie in lines diagonally across the river; small gravel forms the best bottom; and rock, on the contrary, the most dangerous, unless perfectly regular and not slippery. They may be sounded by means of a boat having a pole attached. But cavalry or good swimmers may effect it with lances or poles, carefully feeling their way before advancing.

Parts which may be too deep, or even the whole width, if the river is narrow, may be rendered fordable by throwing in fascines parallel to the direction of the current, and loading them with stones, which must afterwards be covered with smaller material to render the surface level. The approaches should also be levelled, and where the soil is soft, rendered firm by covering them with fascines, &c., so that the troops may advance with a broad front, and rapidly mount the further bank.

The extent and direction of the ford should be clearly marked out by means of poles firmly fixed, and these may be notched, so that a dangerous rise in the river may be observed. If the current is rapid, a number of these placed along the upper edge of the ford, and connected by ropes, will also be useful to prevent men on foot being swept away; and boats and horsemen should also be in readiness to rescue them. The force of the current may be broken by the cavalry crossing a little above them; but if the bottom is sandy, the cavalry should cross after the infantry and artillery, as the passage of the former deepens a ford sometimes very materially.

The opening and shutting of the mill-sluices will sometimes alter the depth of fords, and floods may even entirely destroy them: they can be rendered impracticable by means of large stones, harrows, planks with spikes, sharp stakes driven in so as to be concealed by the water, abattis, &c., or by cutting trenches across.

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* By Captain Bainbrigge, R. E.

† *Vide* Corps Papers, vol. v. p. 9, pars. 6, 7, 8.

END OF VOL. I.

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AIDE-MÉMOIRE

TO

THE MILITARY SCIENCES.

FRAMED FROM

CONTRIBUTIONS OF OFFICERS

OF

THE DIFFERENT SERVICES,

AND EDITED BY

A COMMITTEE OF THE CORPS OF ROYAL ENGINEERS

IN DUBLIN,

1845—1846.

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LIST OF PLATES

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